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[No. 41.]

N.E. COTTON MANUFACTURERS' ASSOCIATION.

PROCEEDINGS

OF THE

SEMI-ANNUAL MEETING,

HELD AT

BOSTON, OCTOBER 27, 1886.

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ASTOR, LENOX AND
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CALL FOR MEETING.

BOSTON, Oct. 11, 1886.

DEAR SIR, — The stated Semi-annual Meeting of the Association will be held at the Massachusetts Institute of Technology, Boylston Street, Boston, on Wednesday, Oct. 27, 1886, at ten o'clock A.M.

Topics heretofore discussed will still be in order if called up by any member; and, in addition, the Board have the pleasure to announce the following: —

Mr. CHARLES T. MAIN of Lawrence, Mass., will present a paper on MILL CONSTRUCTION.

The subject of ROPE DRIVING for the transmission of Power will then be brought up; and Mr. CHARLES H. MANNING of Manchester, N.H., with others, will give the results of their experience and observation in its use.

Mr. CHARLES A. COGGESHALL of Providence, R.I., has been invited to exhibit and explain his new METHOD OF BANDING SPINDLES.

The subject of ENGLISH CARDS AND CARD CLOTHING as compared with AMERICAN, has been assigned for discussion; and members are invited to give results of their observations on the matter.

An early and full attendance is requested.

By vote of the Board of Government,

AMBROSE EASTMAN,

Secretary.

PROCEEDINGS.

PURSUANT to the foregoing notice, the stated semi-annual meeting of the Association was held at the Massachusetts Institute of Technology, on Wednesday, Oct. 27, 1886, the President, Mr. J. S. LUDLAM of Lowell, in the chair.

The meeting was called to order shortly after ten o'clock, and the call was read by the Secretary.

The PRESIDENT. The next business in order is the election of new members. The Secretary will read the names of such gentlemen as have been proposed since the last meeting of the Association, and we will then proceed to ballot for them.

The following list was read by the Secretary: —

Messrs. EDWARD W. ATKINSON, Boston, Mass.
LAWRENCE V. ELDER, Maginnis Cotton Mills, New Orleans, La.
STEPHEN GREENE, Whitefield Mills, Newburyport, Mass.
WILLIAM C. GREENE, Thorndike Co., Thorndike, Mass.
A. F. KNIGHT, Bozrahville Co., Bozrahville, Conn.
HAROLD LAWTON, Lapham's Mill, Centreville, R.I.
M. W. QUINN, Fiskdale Mills, Fiskdale, Mass.
OSMON B. TILTON, Jackson Co., Nashua, N.H.

The SECRETARY. All of these names have been acted upon favorably by the Board of Government, and recommended for election.

The question was then put on the election of each of the gentlemen nominated, and they were severally elected.

The PRESIDENT. At the last meeting of the Association, it was moved by Mr. SMITH of New Hartford, Conn., that the Board of Government prepare such resolutions as they thought fitting, expressing the regret of the Association at the loss of

Mr. CHARLES NOURSE; that the resolutions be submitted to his family, spread upon the records of this Association, and read at the next meeting of the Association for approval. The Board of Government caused this resolution to be prepared, as expressing the feelings of the Association in respect to the loss of Mr. Nourse, and printed in the transactions, which you have doubtless seen: —

Resolved, That, by the death of CHARLES NOURSE, one of the original members, and for many years consecutively a director and vice-president of this Association, we have lost one, who, for more than half a century, was a tireless worker for the advancement of the textile arts in this country. A man of great energy, with a pure heart and heroic character, thoroughly devoted to the interests of New England, it is with profound respect that we record this tribute to his conspicuous services.

If that resolution is in accord with the sentiments of the Association, they will please signify it in the usual manner.

The resolution was approved by a unanimous vote.

The PRESIDENT. The next business before the meeting seems to be a paper upon "Mill Construction," by Mr. CHARLES T. MAIN of Lawrence. Mr. Main is present.

[The paper appears in full at the end of this record.]

The PRESIDENT. Is Professor SWAYNE of the Institute of Technology present? He is about instituting some experiments on mortars and cements, the results of which it is proposed, I believe, to lay before the Association at its next meeting. It is a subject of very great importance to everybody interested in mill construction and hydraulic work. The ignorance about cements and mortars is to-day rather dense; and it is one of the things which it is proposed to bring before the Association at their April meeting, with the results of Professor SWAYNE'S experiments in determining the relative values of different cements and methods of mixing.

Mr. MANNING, who is down on the programme to give us some information respecting rope-driving, I have not seen. Mr. COGGESHALL, I believe, is here. We shall be very glad to hear from Mr. COGGESHALL.

NEW METHOD OF BANDING SPINDLES.

By CHARLES A. COGGESHALL, Providence, R.I.

I AM greatly indebted to your Board of Government for the invitation to speak to you concerning a new principle in banding, which has been patented by myself, and successfully applied to a large number of spindles.

I fully appreciate the privilege by reason of which I am here to-day, and shall endeavor, as a small return for the courtesy extended, to interest you by what I shall say, and in some measure repay you for your attention. In presenting this matter, I only trust that your consideration of the same will be equally generous with the invitation which I am privileged to accept. With a new system of banding appearing for popular recognition, the band question may be said to be revived. I say the band question, because the common method of banding has long, if not always, been recognized as the source of many evils; and it has been a *question* involving much discussion from time to time in these meetings and elsewhere, what to do to lessen or eliminate the evils which have been known to exist. Unfortunately, hitherto this problem has found no practical solution; or at least the evils of the common system have not been removed and lessened only in exceptional cases. Frequent discussion has been beneficial, mainly, in emphasizing the importance of the question; and those who have most fully appreciated the inherent evils of the system, and exercised the greatest care with regard to banding, have suffered the least.

The common method, as I have said, has long, if not always, been recognized as the source of many evils. It might be well therefore, before proceeding with an explanation of the new

system, to consider anew of what these evils consist. The one evil which includes all others may be found in the system itself; or the fact that bands are necessary at all. The time may come (and it would not be so very wonderful if it did, in view of the various achievements of modern ingenuity) when a system of positive rotation at high speed will be devised without the use of bands, or their equivalent evils. But, for the present, we must use bands; and no slight advantage will have been derived if we can reduce their objections to the mininum.

As to the specific evils of the common method: we have, in the first place, the slip of bands, by reason of bands stretching, and the small amount of band contact with the whirl. The result of this evil, it is needless to say, is uneven twist. If a band slips a little, the twist being inadequate, weak yarn is the outcome. If the slip is prominent, the consequence is soft yarn which must needs be thrown away.

Doubtless weak yarn is more largely met with than soft yarn: in fact, it is the rule, rather than the exception, to find at least one weak bobbin at every sizing; and the frequent stops in weaving are often due to weak warps in the loom. Weak yarn, however, does not always imply the slip of bands; for with a positive twist, and absolute uniformity of speed, weak yarn would still be obtained. Nevertheless, there is no doubt but what the number of weak bobbins produced would be materially lessened if the slip of bands could be effectually overcome.

As to the matter of soft yarn, I am not prepared to state the magnitude of this evil: but more or less of this useless product is obtained in every mill, and I may say always will be, since various uncontrollable agencies, aside from the slip of bands, combine to produce this result; such as shaky spindles, heated spindles, rings out of adjustment, broken bobbins, unbalanced bobbins, bobbins that fit the spindles loosely, either from being reamed too much, or being stopped up with waste. But the bulk of soft yarn obtained, be it greater or less, is unquestionably caused by the slip of bands, which is one of the recognized evils of the common method of banding.

Another evil of this universal system is large bands; and right here I may ask the question, Why are large bands necessary? Doubtless, bands will be found in some mills much larger than they need be; but a comparatively large band is necessary for three reasons: first, it is obvious, that, where high tension is required, bands must be large enough to resist the strain, especially in damp weather; secondly, a slight advantage is found in the small increase of driving force from covering a larger surface; and, thirdly, common bands are always tied with some kind of a knot. And I have found by experiment that a knot of any kind will divide the strain unequally between the two strands of the band, so that *one strand* must be large enough to do all the work.

But large bands, as I have said, constitute an evil; and one feature of this evil is a waste of power. The weight of common bands will vary from 100 to 120 bands to the pound, or an average of 110 bands to the pound; at this rate, the weight of bands in a 50,000 spindle mill would be about 450 pounds. If this weight should be put into a large belt with a velocity of from 20 to 30 feet per second, it would prove quite an item in power, which no one would care to tolerate.

Another feature of the evil of large bands is the tendency to variable speed, aside from the slip of bands. In calculating speeds, to determine the ratio of cylinder to whirl, besides other allowances, it is necessary to add $\frac{1}{16}$ inch to the diameter of the whirl; for, by reason of the V-groove of whirl, bands will not be effective at the actual diameter.

Now, it is a fact beyond dispute, and perfectly reasonable that it should be so, that a large band newly put on, being tighter than it will be after running a while, crowds into the groove, and is effective at a much smaller diameter of whirl than other bands which have stretched; and, by reason of old and new bands, effective at different diameters of whirls. When no slip occurred, I have found a difference in speed of spindles of 600 revolutions per minute.

It is evident, therefore, that large bands constitute an evil, not only in adding to the power of a frame, but also in the tendency

to variable speed. A third evil of the common method is *tight bands*, resulting, of course, in a large waste of power; but here we have a condition which is opposed to another already mentioned, viz., loose bands. So that if one is troubled with soft yarn resulting from slip of bands, it is safe to say a minimum of power is consumed: or if one has absolutely no soft yarn, on the other hand it may be taken for granted that much power is consumed in excess of what is required.

Of the two evils, — soft yarn resulting from slip of bands, on the one hand, and superfluous power resulting from tight bands, on the other hand, — the one evil is *seen*, and the other is *unseen*. And as men are invariably prompted to give pre-eminence to the seen to the exclusion of the unseen, it is by no means unnatural or surprising if those in charge, instead of following the familiar maxim, "Of two evils choose the least," unconsiously choose the greatest, and prevent slack-twisted yarn at the expense of power; not that slack-twisted yarn should be tolerated in order to save power, but, in tightening bands to obviate this trouble, the limit is largely over-reached. The case would be different if it were possible to know where to draw the line (or, I may say the band); but, as this is impossible, herein may be seen another feature of the evil which adds to the expenditure for needless power, the cost of which no adequate conception can be had.

But superfluous power (if I may be permitted a word aside from the band question) is not confined to tight bands, but exists also as a result of tight belts.

I have a record of tests made showing the power required for the whole load and shafting alone of eight different mills. The power required for whole load varied, according to the size of mill, from 200 to 750 horse-power. The shafting alone required from 22 to 39 per cent of the whole. As 10 per cent is a reasonable allowance for shafting, it will be seen that in these cases the waste of power was something enormous. I refer to this, as showing the natural inclination of those in charge to ignore unseen evils.

In discussing this matter with a certain overseer, and attempting to show how power could be saved with a system of loose

bands, he said to me, "I care nothing about power, but I *do* care about my twist. If production falls short in the weave-shop, I am sure to hear of it; and I am bound to get my twist at any cost. As to power, the company furnishes that, and no doubt I use a great deal. Why," says he, "I have been in here some mornings, and have been obliged to take up twenty belts before breakfast, in order to start my room. But you wont find any soft yarn."

Here is the view taken by many, in attaching the greatest importance to the *seen*, and paying little or no attention to the unseen. But however much a waste of power is due to a non-appreciation of the question, tight bands are a source of evil which to a certain extent is necessary; that is to say, under the common system, bands must be moderately taut to insure the requisite twist, whereby much power is consumed that might be saved if loose bands would do the work. In other words, power is wasted in the legitimate as well as superfluous band-pull. The required tension of bands depends on the work to be done.

If fine numbers are spun on light spindles, with small bobbin and small ring, the load being light, the band-pull can be less; but if coarse numbers and heavy load, the band-pull must be more. But whatever tension is required, each pound pull is equivalent to about 12 per cent of the power of a frame; so that an average tension of 2 pounds, even, would be equivalent to upwards of 20 per cent of power wasted in band-pull. I say wasted, which, in one sense, is true, because it is no more nor less than spending money for the maintenance of a necessary evil.

As to the proportion of power consumed by superfluous band-pull, it is impossible to speak with accuracy, as the average tension of a room varies from week to week; and, however reliable a boy might be, it is impossible to secure a uniform tension.

Mr. Whitaker, in a paper read at a recent meeting of this Association, gives some interesting data as to power consumed by band-pull, and among other statements makes *this* one concerning a particular test.

"The overseer was instructed, through the regular channels

of communication, to have the machine put in good order for a test, and to be certain that none of the bands should be slack enough to make bad yarn.

"At the conclusion of the tests, the side pull of bands was weighed, and the average tension of bands was found to be 2.6 pounds. One band weighed $\frac{1}{2}$ pound; one weighed $\frac{5}{8}$ of a pound; three weighed $\frac{3}{4}$ of a pound; all others weighed 1 pound or *more*. One band weighed $7\frac{1}{4}$ pounds; one weighed $8\frac{3}{4}$ pounds; and two weighed $9\frac{3}{8}$ pounds each."

"The side pull of the band," says Mr. Draper, "is a very important factor in spinning."

"Upon testing different frames, in different mills, we have found the amount of this side pull to be astonishing to those who have not observed how the matter is managed.

"We have found it in some mills pretty uniformly between four and five pounds; but, in one of the largest mills in New England, we found a difference of from one to sixteen pounds, to do the same work.

"We find in various mills Sawyer spindle-bands, pulling on an average five or six pounds, but frequent, single instances of bands at a tension of ten or twelve pounds, which is more than is required by the old, common, heavy spindles.

"No doubt, even this is exceeded; since we hear stories of bands being tightly tied on the spindles, and *pried* on to the whirl with a screw-driver, or other convenient implement.

"True, there are instances where the overseer appreciates the matter, and gives personal attention to securing as nearly as possible an even and proper tension; but these cases are by no means universal."

It would therefore appear, that while there is nothing which requires a greater human effort than to spend money for that which returns no dividends, yet, if the truth were known, the annual outlay of manufacturers, for superfluous power which yields no returns, would be something amazing.

Doubtless, if some automatic attachment could be applied to the coal-bin, which would pile up in a separate heap as much

coal as is unnecessarily consumed, the cost and magnitude of superfluous power would then be *seen*, and the importance of this evil more fully appreciated.

We have now considered the most important objection to the common method of banding; and we find as existing evils, the slip of bands, large bands, tight bands, the difficulty in securing a uniform or correct tension, and the impossibility of knowing *how much* power is consumed in needless band-pull.

There are other evils of the system, among which may be mentioned the stretch of bands, to allow for which, a high tension is necessary, and the shrinkage of bands, involving a large increase of power in damp weather.

Conscious of these various evils, I set myself to improve the system, or, as implied at the outset, to reduce the objections to the minimum.

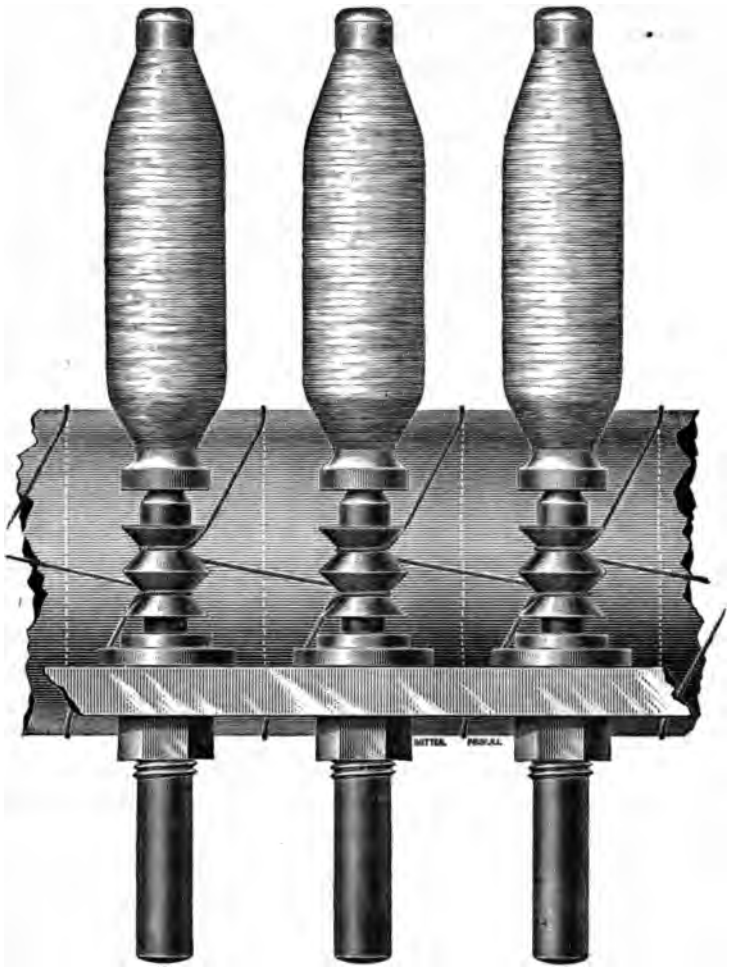
It was evident from the first, that the one thing above all others necessary to be done, was to increase, if possible, the band contact with the whirl.

Notwithstanding prior endeavor in the same line, a record of which was furnished me in the English and American patent reports, I continued to think of the matter till I finally discovered a principle which could be applied in many ways, the simplest form of which I exhibit here to-day, — a principle which soon proved itself equal to removing the greatest objections to transmission of power by means of bands.

In course of time, my model was constructed, and all who saw it admitted without hesitation that the principle would solve the problem, if no impractical features were met with in its operation; in other words, if bands would run well, and wear.

To determine this, as well as to conduct some experiments with a view to further improvements, through the courtesy of Mr. Robert McArthur, agent for the Grosvenor Dale Company, I went to his mill at North Grosvenor Dale, Conn., put the improved method of banding in practical operation, on a frame of two hundred and fifty-six spindles, and, in connection therewith, commenced a series of tests and experiments, which con-

tinued for nearly a year. Of course, many discouragements were met with, and various obstacles presented themselves,



Coggeshall's Patent Method of Banding Spindles.

which seemed insurmountable barriers to success, but concerning which I need not take the time to refer particularly. Suffice it to say, therefore, that ultimately all important objec-

tions were effectually overcome. The method was adopted for all the mills of the Grosvenor Dale Company, and has now been in extensive and successful operation for nearly a year.

It remains now to consider the question, In what degree is the new method successful in removing the objections to the common method of banding?

In the first place, it is evident that the band contact with the whirl is sufficient to prevent slip, and that no soft yarn will be obtained except from other causes than loose bands.

In the second place, the reasons for large bands no longer exist; since the strain is relieved, the additional resistance from covering a larger surface is not needed, and having invented a simple way to join the ends of bands, whereby the strain is divided equally between the two strands of the band, large bands are superseded by small ones; and this, together with the principle of connecting one spindle with another, tends to uniformity of speed, and results in less weak bobbins to a doff.

In the third place, tight bands are done away with. As a result of which, as I have said in my circular, "practically all the power can be saved, which is now in one sense wasted, by the legitimate pull of common bands," and, of course, if superfluous power is consumed, this can be saved also.

We have already considered the question, as to how much power is now consumed in band-pull; but as the question is invariably asked, How much will the new method save? I will answer the question in this way: —

The Messrs. Draper are authority for this statement: —

"A band pulling one pound upon the whirl will drive a Sawyer spindle up to speed, as we know by experiment.

"This is perhaps too low a figure to be practical, but the average tension of bands should not be above two pounds."

Parallel to this I would make this statement, that, with the improved method, a band pulling four ounces upon the whirl will drive a Sawyer spindle up to speed, as I know by experiment (and what is true of Sawyer's is true also of the more modern types). This is perhaps too low to be practical, but it should not exceed eight ounces.

If, then, we accept 2 pounds as the practical pull of the common method, and ½ pound as the practical pull of the improved method, and each pound equivalent to 12 per cent of the power of a frame, then we see that 24 per cent is wasted in legitimate pull, and 18 per cent can be saved.

There are, doubtless, exceptional cases in fine mills where the legitimate pull is less than two pounds, and in such cases less would be saved. It is more probable, however, that the average mill would show an average tension largely in excess of two pounds; and, whatever might be shown, the saving would be proportionate to the amount wasted. In all comparative dynamometer tests, I have never yet obtained a saving of less than 25 per cent, but have found it as large as 40 per cent. So that removing the evil of tight bands results in a large saving of power, the only question being as to just how much.

In the fourth place, the waste of power under the common system is largely due, as has been said, to the difficulty in regulating the tension of bands, or of knowing how much power is consumed in band-pull.

If these features of the problem which I have classed as evils could not be removed, then but a slight advantage would be derived from the new method, as compared with what is possible. Fortunately, however, by a simple device which I exhibit with model, bands can be marked so that any desired tension can be secured, and this tension can be kept practically uniform. By this, I mean, that, under no circumstances, will the variation in tension exceed 4 or 5 ounces; whereas with the common method the tension will vary 4, 5, 6, or more pounds.

In addition to this, the principle of connecting one spindle with another admits of applying a gauge, which I also exhibit, whereby the pull of the band can be readily ascertained, and any unusual variation from the standard tension can be detected and remedied.

Bands can be gauged according to system on the same principle that yarn is sized, a record of same kept at the office, and by reference to which a superintendent may always know the tension of his bands, and be insured against superfluous band-pull.

Finally, we have the stretch and shrinkage of bands to consider. As to stretch of bands, I have found that a common band put on at a tension of three pounds or more, will in time stretch to a tension of one pound or thereabouts, and there remain; but, with the new method, a band with an initial tension of eight ounces or less, being already below the stretching point, will always remain at one tension, subject only to slight variations from atmospheric changes.

As to shrinkage of bands the principle is nearly the same: if a common band at a high tension shrinks in the least, the increase of power is marked; but the same shrinkage of a loose band effects the power but slightly. So that, with the improved method of banding, a greater proportion of power is saved in damp weather; and it is no longer desirable, or of any marked advantage, to find a band not susceptible to variable humidity.

In conclusion, let me refer to three objections which have been raised against the new method of banding; two of which were nominal, the third real, but recently removed.

Some have supposed that if one band should come off, as no spindles would be stopped, but two spindles would continue to run, with but one band to each spindle. These spindles would produce soft yarn.

The fact, however, is this: if one band breaks, two spindles continue to run with but one band to each spindle; but each band has another adjoining, to assist it in doing its work, therefore no soft yarn is produced.

Secondly, it has been alleged, that, in piecing up, the momentary stop of spindle in taking off the bobbin affects the speed of adjoining spindles, and makes soft places in the yarn.

A careful examination, however, has shown this not to be the case; but even if it were so, as there are few ends pieced between doffs as compared with the number of spindles, the breaks in spooling would not be increased to a noticeable extent. At any rate, wherever the method is in practical operation, this alleged objection is never noticed or thought of, and as a matter of fact does not exist.

Thirdly, it has been quite generally understood that bands could not be put on with frames running. Until recently this has been the case; but now bands can be put on, not only without stopping the frame, but are so put on as easily and quickly as the common way.

"There are no obstacles, therefore," as I have said in a card, "in the way of successful and satisfactory operation; and what may appear to be objections to the method will be found to have no other than an imaginary existence.

Having confronted the band question, with a view to its practical solution, or of lessening the evils of the common system, the time has come for manufacturers to say whether or not I have succeeded.

If it shall be found, which is not likely, after so long a trial of the new method, that in any particular I have *not* succeeded, then I propose to pursue the matter till the final secret is discovered.

Capt. Eads once said, when the impracticability of his jetty scheme was suggested, that, "should it become desirable to span the continents with a bridge, engineering science would be found equal to the task." Another manner of saying that "where there's a will, there's a way." So wherever an evil exists, and there are not a few in our mills, its removal may not be said to be altogether impossible, though failure be repeatedly met with. With sufficient patience and determination, and a little encouragement, doubtless the way may be found to match the will.

Thanking you for the privilege of explaining the new method of banding, I now submit the matter for consideration.

The PRESIDENT. Gentlemen, you have heard Mr. COGGESHALL'S very interesting paper. Does any member of the Association care to ask him any questions concerning the system or the device he has exhibited here?

Mr. KENT. As I understand, Mr. McARTHUR has had considerable experience with this new mode of banding. I would like to ask him what percentage of power he saves by adopting this method of banding over the old style?

Mr. McArthur. I do not know that I can add much to what has already been said by Mr. Coggeshall in regard to the saving of power. He made the statement, that the saving had been from twenty-five to over forty per cent. Those tests were dynamometer tests, and were mostly made at our mill. I can indorse what he has said in regard to the matter.

Mr. J. H. Higgins. I would like to ask the gentleman what is the effect of running new and old bands together on the same spindle?

Mr. Coggeshall. I do not know that the effect is any other than if they were both new bands, or both old bands. If we should continue to use large bands, then the old band would slip a little. With small bands, the case is altered; because small bands, whether old or new, run at the same diameter of whirl, which is not the case with large bands.

Mr. J. H. Higgins. How many spindles banded in that manner are in operation?

Mr. Coggeshall. Some over fifty thousand.

Mr. J. H. Higgins. Has that point been tested, in any way, to know whether, if the two bands are run together, one operates detrimentally to the other?

Mr. Coggeshall. It has been tested in this way, — that, if there is a defect in any system, it will be manifested, presumably, in some way. If any defect exists, we find it somewhere, either in power, in the quality of the yarn, or product. If these things are all right, then we conclude there is no detrimental defect.

Mr. H. F. Lippitt. I would like to ask why it is that the gentleman says, that, when one band comes off, the spindle runs at the same velocity, or that there is no soft yarn? Why is it necessary to use two bands then?

Mr. Coggeshall. If one band comes off, under this system, there will be two spindles with but one band on each spindle. The one band that is on each spindle has another one to help it. Consequently there is no loss there. But if two alternate bands should come off, leaving one intermediate band to drive two spindles all alone, that band could not do it.

Mr. LIPPITT. What would be the consequence then? Would the band break, or would there be soft yarn?

Mr. COGGESHALL. The consequence would be soft yarn. But that thing don't occur very often. In fact, I don't know as I ever saw it occur. There would be soft yarn if it occurred; but it don't. Two bands are necessary for the sake of cylinder resistance.

Mr. BROWN. If my memory serves me, the gentleman stated that he found a difference of six hundred revolutions due to the difference in the size of the bands. That being the case, I can hardly see how he can use a large and small band on the same spindle without any appreciable difference.

Mr. COGGESHALL. We do not run large and small bands on the same spindle.

Mr. BROWN. Then I will say with bands of different sizes.

Mr. COGGESHALL. We do not, under this method, run different sizes. We run bands of uniform size right through, much smaller than the uniform size of the old method.

Mr. BROWN. I will say with new and old bands.

Mr. COGGESHALL. There is no difference in size between old and new. When I spoke of the six hundred revolutions difference, I referred to the common method of banding, where large bands are used. I do not know that I made myself quite clear. The actual diameter of the whirl that we use is three-quarters of an inch. The band will not run constantly at this exact diameter. If the band is new and put on tight, it goes down into the groove, under a high tension, to the small diameter, and runs the spindle fast; but after a while the band stretches and gives way, so that it runs at a much larger diameter, and therefore runs the spindle slower. That was an evil with large bands which it was important to overcome. We have found that we can use a small band; and the bands are so small that they run practically at the actual diameter of the whirl all the time, no matter whether they are old or new. In considering the common method, we speak of new [illegible] nds in the sense that new bands are tight, and old [illegible] new bands are large, and old ones small.

Under the new system, old bands are practically the same tension as new bands, and this tension is insufficient to create a marked variation in speed, even if large bands were used.

The fact that we can use small bands, helps the matter all the more.

Mr. McArthur. That is true about the bands. We do not have that extreme tension of the band by Mr. Coggeshall's method, that we do in the case of spindles banded in the usual way; consequently, they do not draw down small, they remain substantially at the original size.

In reply to Mr. Kent's question, I will say this, in order to illustrate the benefits that may be derived by using Mr. Coggeshall's method of banding spindles. We will assume that we have a mill which contains ten thousand spindles, and that we band them by the ordinary or common method. If we drive them at a velocity of eighty-five hundred revolutions per minute, that would require not less than one-hundred-horse power. That, of course, is a low estimate. How much is this one-hundred-horse power worth, or what would it cost to produce it? If it is developed by steam, it will cost not less than forty dollars per horse-power per annum. If one horse-power will cost forty dollars, one hundred will cost four thousand dollars. Now, if we adopt the Coggeshall method of banding, we can save at least twenty-five per cent on these ten thousand spindles. That is a low estimate of the saving of power. That is equal to a money value of a thousand dollars per annum. This saving of power would be sufficient to enable us to keep the whole ten thousand spindles in good repair continually, or it would produce a saving in money which would purchase new spindles for the mill every ten years. That is the way I reasoned the matter when we went into it, and our experience has demonstrated that it is true.

A Member. There is a little point I wish to bring out. A band has become reduced in size from tension, from wear, and the time comes when we put in a new band in connection with it; there is greater tension, it is effective, and shows in the matter of power. That is the way I reason it. Perhaps I may be all wrong.

Mr. McArthur. We have over forty thousand spindles banded in this way, and the tests which have been made have been made in this way. The dynamometer has been put upon frames where old and new bands were used; no selection has been made whatever; we have been particular about that whenever we have made a test. We have not allowed them to know which frame we would test; they have taken them at random.

As for soft-twisted yarns, I will add, that, in my experience as a spinner for some twenty-five years, I never had so little as we are having at present.

The President. In the absence of any other matter, Mr. Draper, of whom you have heard before [laughter], has a little matter about spinning to which he would like to call your attention.

Mr. George Draper. It has been announced that you have heard from me before. [Laughter.] I am reminded that you will not hear from me many times more. You may be sure of that, and take all the comfort you can from it. I am reminded of it by the resolution just passed with reference to the death of Mr. Charles Nourse. I am reminded of it by the memory of David Whitman, S. J. Wetherell, Gov. E. A. Straw, A. D. Lockwood, Josiah Lasell, N. A. Farwell, and James A. Dupee, who left us only a few days ago, and many others, all of them my friends, and most of them gentlemen with whom I have discussed these matters here and elsewhere. But, as I say, I am coming to that time of life and to that state of things, where I feel that I cannot expect to take part with you much longer. I am not disposed to complain of that. I am disposed to look to the past with cheerfulness, and to the future with faith and hope.

But I have something to say to-day, and you will excuse me if I am somewhat dogmatical. I am going to talk of something I know about, whether you gentlemen do or not. [Laughter.]

Mr. Atkinson. *Mr. President*, — There is an old saying, "The King is dead! Long live the King!" [Applause.]

Mr. DRAPER. I was about to say that this thing of which I am going to speak is the only thing that I have brought before you, on which, if I made a good impression on your minds, I was not going to make some money. It is a thing, which, whether you adopt it or not in your spinning, will make no difference to me, in a money point of view. And let me tell you, that I have been more discouraged in trying to give away one of the best things I ever had to do with, than I have been in trying to sell any thing to you. I will say, for I believe, that if we had charged twenty-five cents a spindle for the use of the invention, and had gone to work and employed men, and followed the thing up, with the interest that would have given us, we could have sold you more eveners than you have taken for nothing. I have no doubt of it. The fact is, it is a question of education. This young man who has spoken of a new system of banding has my sympathy. I can tell him, if he has the best thing in the world, he has got a hard job before him. The fact is, you gentlemen are busy men. I know that very well, for I have had some experience. I have been in the same business myself. You have so many things pressing upon your attention, so many men calling upon you all the time with one thing and another, telling you about each one, "There's millions in it!" You must give your attention to these matters, and accept or reject them; and you find it difficult to decide just what you will do, or what you won't do. I appreciate the difficulty just as much as any of you. But there is one thing about it: there are certain things that are true, whether you see them or not.

Now, my observation in dealing with you, gentlemen, has been that you have somewhat different characteristics. I could point out A, B, and C, perhaps, of whom I should know that every thing they bought would be the thing they could buy for the least money. They would be made to believe in it. And the thing that is the poorest, as a rule, the agents say the most in favor of; they have got to, to sell it. They will say of what another man has to sell, "It is good for nothing: this thing that we have got is far better." And, the poorer the thing is,

the more loudly they will expatiate upon its merits; and you will buy of those men, because you know you have not got to pay out so much money. I say the most successful man is the man who can pay out the most money, and make the largest percentage upon it; it is not the men who do not do any thing. There are men who can make money by these operations.

Now, before I forget it, I want to say one thing. I have a pamphlet written by Chauncey Smith, setting forth the effect of inventions upon civilization; and I have been so much interested in it, that I have asked Mr. Smith to have enough printed to furnish each member of this Association with a copy. I will see that the Secretary has them, and ask him to send one to each of you. You will find in those few pages something that will interest you as much as any thing you have ever read, I believe. It goes right to the root of the matter, whether we shall go on making improvements, whether we shall stay where we are, or whether we shall go back. I sometimes hear men who have charge of mills saying, wearily, "Oh, I wish they would not make another single invention! If we could only go on as we are, and not be obliged to compete with new inventions, not be obliged to get new things, we should be all right." But the car is going on; and if you do not jump on, and avail yourselves of the various improvements as they come up, you have got to suffer for it.

There is another thing which makes it more difficult to get along. One man can play better upon an old fiddle, than another man can on the best fiddle you can find. One man will tell you, "I can do so and so with my old machinery." I heard a man — a successful man; a man who is supposed to be worth a million dollars, made by manufacturing — say in the cars, within three days, "I can take that old machinery [he had just bought a lot of old machinery], I can get labor, and get more out of that old machinery than other people get out of their newest machinery." I said, "That is because you know how to run old machinery, and you don't know how to run new. There are some men who can beat you all out of sight."

Let me come to the question that I propose to talk to you about. The gist of that question is, not as to using the frame as against the mule, — I shall leave that out of sight, except to say, as I have said before, that you could not afford to take mules, if you could get them for nothing, for spinning filling, say of No. 36. In this connection, let me say that I have seen a report within three days, that came from Mr. Scott of the Willimantic Linen Co., in which he stated that he was spinning No. 140 yarn to put into thread, that the yarn broke six per cent stronger than that made on mules, and that he could produce it at one-half the cost for labor. If the mule is going to fight that state of things, it will have a hard time.

Now, if there is a man here who does not, or any number of them who do not, believe that the evener is a good thing, who thinks he understands it, and can give his reasons against it, I wish he would come forward, and let me ask him some questions about this matter, and see if I cannot convince him that he is mistaken, and convince you that he is mistaken. I am sure he is mistaken anyway. If he will answer "Yes" or "No" to the plainest questions, and go through with this mechanism, I have no doubt I can show the operation, so that any man can see it.

I say, take this frame, take off that cone which drives the front roll, and put on a straight pulley; that is a frame without the evener. By using the cone in connection with the rolls, it becomes a frame with the evener. The object of putting this cone on, is to drive the front rolls at different speeds.

I am prepared to maintain these propositions: —

First, That, with the evener on, we can spin yarn more slack twisted, every thing else being equal.

Second, That we can wind the yarn tighter on the bobbins.

Third, That we can spin on smaller barrel bobbins.

Fourth, That we can put more yarn on the bobbins.

Fifth, That we can wind the bobbins so that the yarn will weave off with less waste and breakage.

Sixth, That we can run the frame at a higher speed, to good advantage.

Seventh, That we can spin yarn at less cost per pound for labor.

Eighth, That we can spin a given quantity of yarn for less cost per pound for room or machinery.

Ninth, That we can weave the yarn when spun at less cost.

Tenth, That we can weave the yarn when spun with less waste.

Now, there is a mill that has adopted this plan substantially. They have every spindle in the mill, warp and filling, on the frame plan, and they use our evener on the frames. It is a mill of 35,400 spindles, with new machinery, which has been running about a year and a half. The mill is four stories high. All the spinning for the whole mill is done in one room; it does not take up two rooms in the mill, as it would if they had mules. The carding occupies one room; the looms occupy more or less of two rooms, with spooling, warping, etc. That mill, last year, ran three hundred days. They have 920 looms and 35,400 spindles, and they made and sold fourteen million yards of print goods, that brought as high as any cloth that is sold in the market; which is 50.75 yards for every loom in the mill, for every working day in the year.

Now, if a mill can do that, — and it is doing it, for I have seen the bottom line of what they have done, and how much they made; they bought the cotton on the market, and sold the goods every week on the market, so that there is no doubt that they have made the money, if they have made it at all, by manufacturing, and not by speculation, — if, I say, a mill can do that, can you find a mill with mules in it, or with frames in it without the evener, that can match it? If you can, you will be luckier than I should be in knowing where to find it.

Now, about this matter, is there any gentleman here who really feels that he knows what this evener is, and that there are objections to it? If there is, I would like to hear from him. If there is not, I will proceed to say what I have to say about the matter.

In the first place, what this evener is for, is to vary the speed of the front roll; the back roll and the middle roll run at the

same speed all the time. Now, you all know, who know any thing about the matter, — and, while you all know something about it, I don't think you know as much about it as it would be for your interest to know, — you all know, I say, that if the front roll runs at a uniform speed, it will produce what is *supposed* to be an even twist per inch, and an even size of yarn. When we vary the speed of the front roll, from eight to one of the back roll, to nine to one of the back roll, we reduce the yarn in size, and vary the amount of twist in proportion to the difference of speed of the front roll. That is a plain case. Now the question is, what do you want the evener for? I agree, that if we were running right along at the same speed all the time, if the conditions of winding this yarn or spinning it on the bobbin were the same all the time, we should not want to use it. There is no doubt about that. But the conditions of spinning filling on the bobbin, as we do it here, are constantly changing. In the first place, we want to spin on this small barrel of the bobbin; in the next place, we want to spin on the largest part here; we spin conically, in this way. [The speaker illustrated, by reference to a frame in the room.] There is no spinner here who does not know that when you spin on the barrel of the bobbin, every thing else being equal, you are going to draw your yarn much harder, because it is driving the traveller round the ring at a great disadvantage compared with what it is when spinning on the largest part of the bobbin, and at the same time putting in less twist. I don't think there is anybody present who will pretend to dispute that fact. If that is the case, what are you going to do to provide for it? I will tell you what you can do. You can twist that yarn so much that you can get along without the evener; that is to say, — to illustrate, — you can put the belt on the smallest part of the cone, where it will make the most twist and the coarsest yarn, and keep it there, if that is what you want to make. If you want to make hard-twisted yarn, and are always going to, you might not need the evener; although even then the evener would be a more practical contrivance, but you can get along without it.

I want to say one thing while I think of it, in regard to the

evener. I want to tell you all the outs there are about it. In the first place, there is the cost of the thing. In putting this thing on your frame, you are putting on a cost of say fifteen cents a spindle. If there is no use for it, if it will not do any good, that will settle the question. There is another thing. You have got to oil these bearings, you have got to keep these parts in repair and in shape, and there is a little power consumed in driving it. That is every thing that can be said against it, except that you must have a man to run it, who knows how. If you have a man to run it who will run it wrong end first, make the front roll run faster, when it ought to run slower, than the others, and all that sort of thing, you will have trouble. It is like every thing else that is good, it can be abused.

Now, then, I say, it is plain that you are going to have your slackest twisted yarn where you get the most strain on it by the bobbin. Every time the yarn winds round the bobbin, it loses a turn of twist. It winds round a great many more times in a given length, where the bobbin is small, than where it is large, as you have a decreased twist; when winding on the barrel of the bobbin you have an increased draught also, and the effect is to absolutely stretch that yarn. I tried experiments for twenty-five years, and I found that the yarn stretched perceptibly, and I went to work and got up this evener, in order to make the yarn size alike on the barrel, and on the outside of an ordinary warp bobbin.

I have not come into this thing rapidly. It has been a matter of growth with me. I have found out the foundations of it. I know what I am talking about.

Now it is evident enough, as I say, that you are going to subject the yarn to more strain, and it is going to be less able to bear it, on the barrel of the bobbin, than on the outside. What are you going to do? You cannot stand that. Every man who has an evener, and stops its operation, goes to work to put in more twist. The old evener which I introduced on the railway-head some people said was an *un*evener, and they took it off. Mr. Nelson Slater has not got rid of that idea up to this day. He is the only man in the country who runs a railway-head

without the evener. He asked me if, under certain conditions, the evener would not make the yarn less even than it would be without it. I said yes; but on the average it made the sliver two or three times as even as without it: and because I admitted that under certain conditions it operated the other way, that was enough to keep him from using it.

Now, in regard to the matter of introducing this thing, and people getting acquainted with it, some of our best machinists, who ought to know better, are going about the country, and, finding that their customers want to buy a frame as cheap as they can, they tell them they can sell a frame cheaper without the evener than they can with it, and A, B, and C say it is good for nothing; and in that way they have caused you to believe, and are causing you to believe, that you had better buy a frame without the evener, than pay this additional fifteen cents a spindle and get a frame with the evener. I say it is as plain as the nose on your face that that is not so. This ring rail traverses up and down in filling the bobbin. This ring rail has an exact motion, and is always at the right place at the right time. Now, then, we just attach something to the same thing which operates this ring rail that moves the belt on the cone, to exactly correspond with the part of the bobbin that is being wound. Nothing could be more simple, and nothing more sure to work just as it is intended to, than that is. Now, as you see, that enables you to arrange this cone so that you can make the yarn, if you please, a little stronger when winding on the barrel of the bobbin; you can make it a little coarser, and put in more twist, both at the same time. You can do just as much or just as little with it as you find for your advantage.

Now the question is what this evener does? I am sorry to say that there are comparatively few men who are made up right to try experiments effectually. They get theories and ideas in their heads which they want to sustain. If you go into a mill with something new, and want the man to try it, and he finds that you think favorably of it, in nine cases out of ten you will get a favorable report. The man may think he is telling the thing just as it is, that he is stating all the outs there are

about it, but in nine cases out of ten he is not. He wants to please you, and he will make just as favorable a report as he can. I can tell you a single instance where I was a sufferer by a favorable report that was made to me. I was about making a contract in a matter with regard to something on spinning frames. I had the power tested by a man in whom I had confidence then, and in whom I have confidence to-day, only he was not careful enough. He said, after trying certain experiments in connection with banding, spinning, etc., that he found there was a saving of twenty-five per cent of the power. Said I, "Are you sure there was twenty-five per cent of power saved?" He said there might be a little variation from that. "Well," said I, "where will you put it, and say that you are sure you are right?" He said, "I will put it at eighteen per cent." On the strength of that I made a bargain which will cost me about fifty thousand dollars. Within a short time I have paid forty thousand dollars, and expect to pay the other ten thousand dollars when it becomes due. Experience got in that way is worth something! [Laughter.]

There is a man who has experimented for me for more than twenty years. I knew he was a good spinner. He has been trying experiments in various ways on spinning. I have found that if a thing did not go as well as I thought it would, he would tell me so. I have learned that he tried experiments to find out facts, and he told me the facts as they existed; and that, to a man who is trying to improve things, is of great value. That is the man whom I have had trying experiments on this frame. I don't think it is wrong for me to say that it is Mr. WILLIAM WELCH, whom many of you have seen, and who served twenty-two years as a spinner in the same mill, and nobody beat him in his business there. I only mention this to say that he tried these experiments on the frames years ago, started up and run those frames on 36 filling or thereabouts, and knows all about it.

Mr. C. D. MCDUFFIE. Will you please describe those print cloths? how many picks there are to the inch?

Mr. DRAPER. They are standard 64 goods.

a pound and a seventh filling and warp, on the average, in the cloth per week, for every spindle they have got; and they have done it very low, because, if the rest of you could make print cloths and make as much money as they did last year, you would be building print-cloth mills right off.

Mr. EDWARD ATKINSON. Don't tell any thing about it, then.

Mr. DRAPER. I will not tell any more particulars than that. The number of yards produced in that mill, and sold and paid for, was 14,009,082, in three hundred working days, and they don't allow them to run but ten hours a day in Massachusetts.

A MEMBER. Are you sure about the ten hours?

Mr. DRAPER. Under the law of Massachusetts they cannot run but ten hours a day. Mr. Robert Howard is there, and looks after them, and I don't believe he allows them to run much more than that.

Mr. T. B. WATTLES. They have run from 200 to 207 picks.

Mr. DRAPER. My impression is, that they are running too high, but I don't believe they are running 200.

Mr. EDWARD ATKINSON. As nearly as I can figure it, they must have been running about 200, or else the proportion of time the looms were stopped must have been a great deal less than usual.

Mr. DRAPER. This is what you can understand. Under this process they do not have to stop looms so much. That is the very point. When you put more yarn on the bobbin, and when it does not break so often in weaving, so that you are obliged to stop your loom, you are going to weave more: your loom is not going to stop the same percentage. That is just what I claim.

Mr. ATKINSON. As I figure it, assuming exactly fifty yards, there must have been a speed of a hundred and ninety-two picks, provided the looms ran all the time without any stoppage.

Mr. DRAPER. I have got the returns from a mill which claims to make ninety per cent of full production, — a good mill, too, — and they are people who, I believe, tell the truth. But at that mill they have excellent carding, and they have this

system of spinning. They made up their year's account a short time ago; and I know these figures came right from their books, and that they sold their product right off. There was no surplus at the beginning or end of the year. It is simply the production that they turned over week after week. There can be no mistake about it.

Mr. J. H. HIGGINS. I suppose Mr. Draper will admit that they have good weavers?

Mr. DRAPER. I hope they have. They ought to have. They can get the best weavers where the work runs the best.

There is one point that some people undertake to make against this thing, that I want to say something about, and that is this. They claim that the variation of the speed of the roll makes more uneven yarn; that is the argument that they make. It is just the same argument that they made against the evener on the railway-head. Now, I say, — and I have no doubt of what I am talking about, and I can prove it to you if you will follow the thing, — I say that I have no manner of doubt that the yarn is really and truly perceptibly evener with this than it would be with the other system; that is, to bring down the twist to what we call a low twist. As I said to begin with, if you are going to twist hard enough for warp, perhaps you cannot tell the difference.

Mr. DANIELSON. How large a variation is there in the speed of the front roll?

Mr. DRAPER. You can regulate it just as you please. There is no difficulty. It depends entirely upon the shape of the cone, and how far you will traverse the belt on the cone. It is perfectly within your control how much you will vary. I made up my mind to vary about eight per cent; that is to say, four per cent each way, with the average draught. Four per cent slower than the average when you wind down on the barrel of the bobbin, and four per cent faster on the outside of the bobbin. It is changing all the time as it goes the length of that cone. It spins about three hundred inches in the time that it is going from one extreme to the other.

Mr. DANIELSON. According to that, if you were spinning

No. 25 yarn, when the cone is at either extreme, it varies four per cent from what it is at the centre. It would be 24 in one case, and about 26 in the other.

Mr. DRAPER. In my experiments, I tried No. 36 yarn where it would make, as I have said before, rather more than a number, as I understand it, difference. But if you were going to spin No. 25 yarn, you would lessen the distance it was to traverse. What I say is, that the tendency of the yarn to stretch when we come down to the bobbin, that we have without it, is made up for with the evener, by making it slightly coarser than we otherwise would; but, on the whole, you have got evener yarn. If you suppose that you are going to have perfectly even yarn, without the attachment, then I am ready to admit that you will make it uneven with it. But that is not the case. This corrects the unevenness which you would have without it, to a greater or less extent.

Mr. DANIELSON. Do you mean unevenness in the twist or in the draught?

Mr. DRAPER. I mean both. It will certainly correct the unevenness in the twist, and it will correct the unevenness in the draught. Gentlemen, if you will just take one of these frames, there is nothing where you have a better chance to try experiments, and know all about it, than in this machine, if you will only give your attention to it. It is perfectly within the control of anybody to try that experiment, if due care is used.

Mr. WATTLES. Can you try the experiment by simply stopping the shifting of your belt?

Mr. DRAPER. That can be done; but in trying your experiment, the question is, where you are going to leave your belt?

Mr. WATTLES. In the middle.

Mr. DRAPER. It may not be exactly in the middle. How do you know the man is putting it there? You have got to be very careful in trying an experiment. I have been in a mill where they stopped the evener, but what had they done? They had the belt where they ran the coarsest twist, and they said it ran better without the evener than when the evener was on. I recollect that in another factory where I spent a great deal of

time in inducing the agent to adopt the evener on the railway-head, I found when I went into it (and it was a pretty good mill) that they didn't like to see the trumpet going backwards and forwards; and what had they done but put a strap and a weight on it, and hung it up to try to restrain it, when the whole virtue of the thing depended on its moving freely. [Laughter.]

I am afraid that if this is to be the last time, which I won't promise [laughter], that you are weary with me.

A MEMBER. If we thought it was to be, we should want you to talk all night.

Mr. STILES. I can vouch for the correctness of the statements that Mr. Draper has made in regard to the evener. We have been using it in our mill for five years. Last week, without any view of saying any thing here, and not knowing that this question was to be brought up, I consented to let the overseer try an experiment. He had been going round to different mills somewhat, and had been told that the evener was not of any account, and did not make any better yarn. To satisfy himself, he stopped the traverse of the evener-belt on one-half of his "filling frames," and found in a short time that his girls could not keep their work up. The frames ran this way until they were in quite bad condition. Then he set the evener at work, and very soon these frames were running as well as the others, which is all the proof I want of the value of the "evener" for spinning filling on frames. I have not made any experiments to tell you how much finer it is on the larger part of the cone, and how much coarser on the smaller part; but there is the fact, that the spinning ran more than fairly well with the evener running; and in three hours' time, with the evener stopped, his spinning was bunged so that he could not run it. And after starting the evener, within an hour's time, he had that work running as well as it was in the other half of the room.

Mr. DRAPER. I do not think there is any gentleman in this room who is engaged in manufacturing, that has had any more experience than Mr. PARKER of the Pacific Mills. I have not

conversed with him on the subject for a year or two. I do not know but he may have made up his mind that the thing does not amount to much. If he chooses to give us the benefit of his present state of mind on the subject, I would like to hear him. I will take the risk.

Mr. WALTER E. PARKER. I have not any facts to present to the meeting to-day, not knowing that the question was to come before you. I can say that there is an undoubted advantage in having the evener upon a filling frame. The first experience that I had with spinning filling on frames was without the evener, and afterwards I had some experience with the evener; and I thought I proved that the evener was a decided advantage. We have frames at present arranged so that we can change them from warp wind to filling wind, and we do not have an evener on the frames; and we have to put more twist into the yarn that we spin, because of the lack of the evener. We calculate, however, to run the frames so that the yarn will weave well, and that can be said of all the numbers up to No. 41 that we have spun. I have not any facts to present to contrast the difference between a frame with the evener and without.

While I am up, I would like to say, that it has been our custom to adjourn about noon for lunch, and then come back here with two or three papers, perhaps, to read, and very few of the members to hear them. I would like to suggest (I do not know that a motion is necessary), that we finish up our session to-day before going to lunch, that the persons who have been invited here to speak may be heard by a full house.

Mr. DRAPER. I want to make one announcement only. If I have succeeded in interesting you, gentlemen, so that you want to read about this filling spinner, I have caused some circulars to be brought here which will partly go round, at any rate, and they have the whole subject in them; and I have also a package of yarn-tables; that is, giving the breaking-weight of yarn in American mills, represented by the average of good yarn

that our people have taken a great deal of pains to get from different mills about the country, and you are welcome to any of those tables, for what they are worth. We have tried to get something that would be a standard table for American breaking-weight of what would be called good yarns, and they will be here for distribution.

I do not desire to take up any more of your time; and, unless some gentleman wants to ask me a question, I would prefer to retire.

Persons desiring more information about spinning filling on ring frames will please write to George Draper & Sons for a copy of their filling-spinner circular.

The PRESIDENT. On that subject of breaking-weights, it seems to me that something might be done by this Association, that would be of benefit to everybody engaged in the manufacture of cotton yarns in America. Mr. DRAPER was saying to me before the meeting to-day, that he had very nearly uniformly found the breaking-weights of American yarns of a certain number somewhat higher than were given in the English tables. What I was about to suggest was the propriety of this Association causing to be prepared a standard apparatus for testing the breaking-weight of yarns, to which others might be referred. I have found in my own experience, and I dare say it has been the experience of others, that if you go to a mill, and ask what numbers they are making, and take home a bobbin or two of yarn in your pocket, when you come to try it on your own machine, you find there is quite a serious discrepancy in the numbers. I hear this complaint everywhere; and the only way that has occurred to me by which it could be cured, would be to have a standard to which all the machines we have could be referred. It would not be a serious matter of outlay for this Association to undertake; and it seems to me that an apparatus of that sort might be, if necessary, lodged here in the Institute. There is no difficulty about getting at it. I have no doubt that the management of the Institute would take charge of the apparatus; and any one wishing to compare his own testing and num-

bering machines with the standard belonging to the Association, could do so at any time. Likewise, any differences of opinion respecting the numbers of yarn could be settled by this machine. You would thus, at all events, in your comparisons with your neighbors or competitors, know whether or not you were talking about the same thing. I venture this as a suggestion. If it seems worth while, it might be well to act on it. I know I have hardly ever brought home yarn from another mill that numbered what it purported to be, even when done within an hour and with the same atmospheric conditions. There is doubtless a "personal equation" here, but it cannot account for the large differences found in numbers where the persons testing are reasonably competent.

I simply throw that out as a suggestion; but, if it seems worth while, it might be very well to act upon it. I know I have never found yarn from any other mill that sized up and numbered exactly what it purported to be, when I brought it home and tried it on my own device.

Mr. EDWARD ATKINSON. I would say, that, during an investigation of the strength of cotton yarn conducted by Professor LANZA, some most ingenious devices to test the strength of a given number of fibres were invented by him. I suppose that apparatus is here. His report never found its way into print. I believe it was made for the census, not yet published.

The PRESIDENT. One of the other subjects proposed for discussion at this meeting was ENGLISH CARDS AND CARD-CLOTHING. You all know how deep an interest has been felt in English cards of various devices and builds, during the last eighteen months, in this country. If any gentleman has any information to offer on the subject of cards and card-clothing, we should be glad to hear from him.

Mr. PARKER. I would like to hear from Mr. EDWARD W. ATKINSON on that subject. I think he is well informed upon the matter.

Mr. EDWARD W. ATKINSON. I have been asked to speak upon the subject of English cards; and, as I represent the firm

here who are agents for Dobson & Barlow, I shall be pleased to describe the operation of their cards.

I suppose it is not necessary to dwell upon the method of setting an ordinary revolving-top flat card. The card of Dobson & Barlow presents some new features, which I think may prove interesting. I think you all recognize the importance of being able to have your flexible at all times concentric with the circle of the cylinder, no matter whether the wire is long, or whether it is ground down short and nearly worn out. In the ordinary method of setting the revolving-top flat card, there is no provision made to absolutely insure the concentricity of the circle described by the wire of the flats, with the circle described by the wire of the cylinder; that is left entirely to the skill of the grinder or other person who sets the card.

The setting which has been devised by Dobson & Barlow, which I may say is an entirely new setting and has been only recently brought before the trade, does make provision for and does absolutely insure that the circle of the flexible shall at all times be concentric with that of the cylinder in any condition, whether of new and long wire, or of old wire ground down. The flexible is made somewhat stronger than on the ordinary card. It has projecting at five points a steel pin. Three of these pins rest upon brackets shown at *A A A*, Fig. 1. *B* is the end of the flexible toward the doffer. It is connected by the pin *C*, with the link *D*, which is free to swivel on its centre. The pin at the other end, on the licker-in side, comes on the under surface of the bracket *F*, as shown in the figure.

Now we will suppose the flexible to be in the first position; for instance, that the wire is new, and has been ground for the first time. The pins will rest upon the upper points of these brackets (see *G G G G*, Fig. 1). The link will be in the position as shown at *D*, and the circle described by the flexible will be concentric with that of the cylinder. Now suppose that the wire has been ground down short. It is necessary both to lower the flexible, and also to bring it into a smaller circle, in order to make it concentric with the circle of the cylinder after the grinding has taken place. Under the ordinary system, the

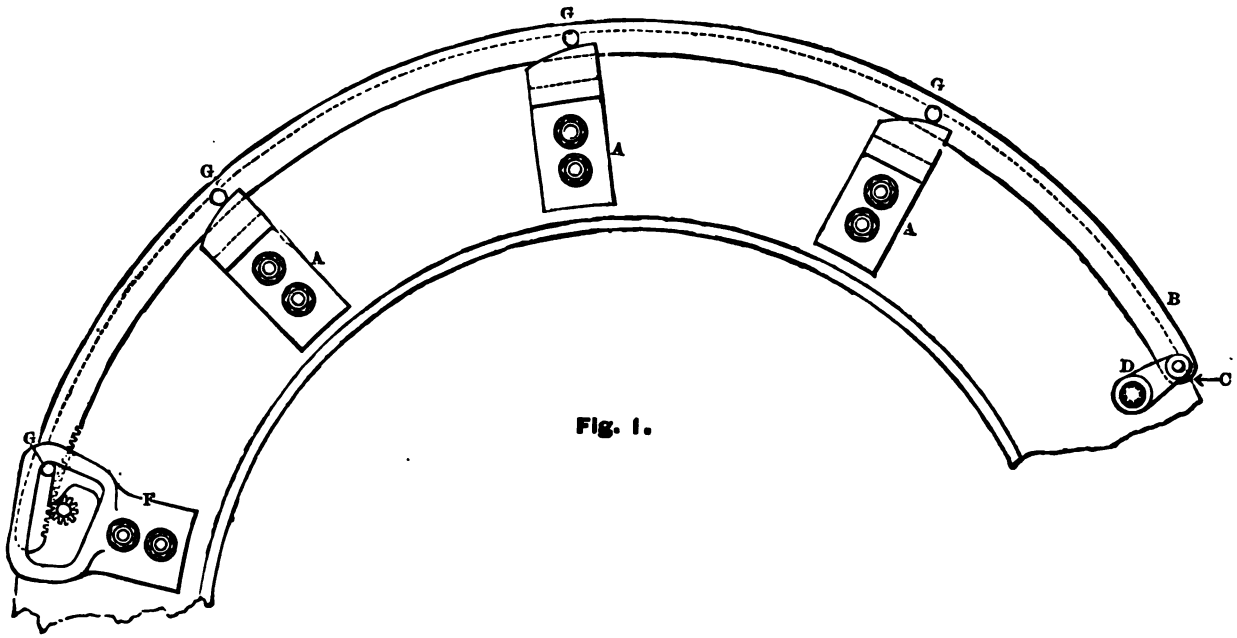


Fig. 1.

judgment and skill of the grinder is relied upon to secure this concentricity; and, after he has brought the flexible to what he supposes to be a concentric position, there is nothing then to insure that this position will be maintained.

The Dobson & Barlow flexible in its last position is shown in dotted lines (Fig. 1). On the end towards the licker-in, on its under side, is a finely cut rack. Into that rack works a worm-wheel. That worm-wheel is connected by a train of fine gears with a setting-handle and dial-plate (Fig. 2). The object of this arrangement is simply to drive this flexible round, and bring it into its various positions on the brackets *A A A*, Fig. 1. The curves on these brackets are so constructed that they represent actually and theoretically the curve described by each pin on the flexible in its motion around the circumference and towards the centre. The link *D*, Fig. 1, when the flexible has got into its last position, is drawn more towards the centre, and therefore the distance from the centre of the pin *C*, to the centre of the cylinder, is decreased. The length and position of the link are so determined, that, as the flexible is drawn forward on the brackets, it shall be drawn toward the centre by the link, in exact proportion. The bracket *F*, on the licker-in side, is put on the outside of the pin, so that as the flexible is drawn forward, this end shall be pressed in toward the centre.

The result is, that when you get the flexible set in the last position in which you want to put it, you really know that it is absolutely concentric with the circle of the cylinder. In a series of experiments on this flexible, tried at Dobson & Barlow's establishment, they have been unable to find a greater variation from perfect concentricity than a five-hundredth part of an inch, at any point in the downward traverse of the flexible from new to old wire limits.

This is all I have to say about the flexible bend, or the method of setting, with this exception, that the whole motion and setting of each flexible is controlled at *one* point. It can be set as finely as to a two-thousandth part of an inch. They do not pretend to measure as finely as that, but if they have got within a five-hundredth part of an inch they think they

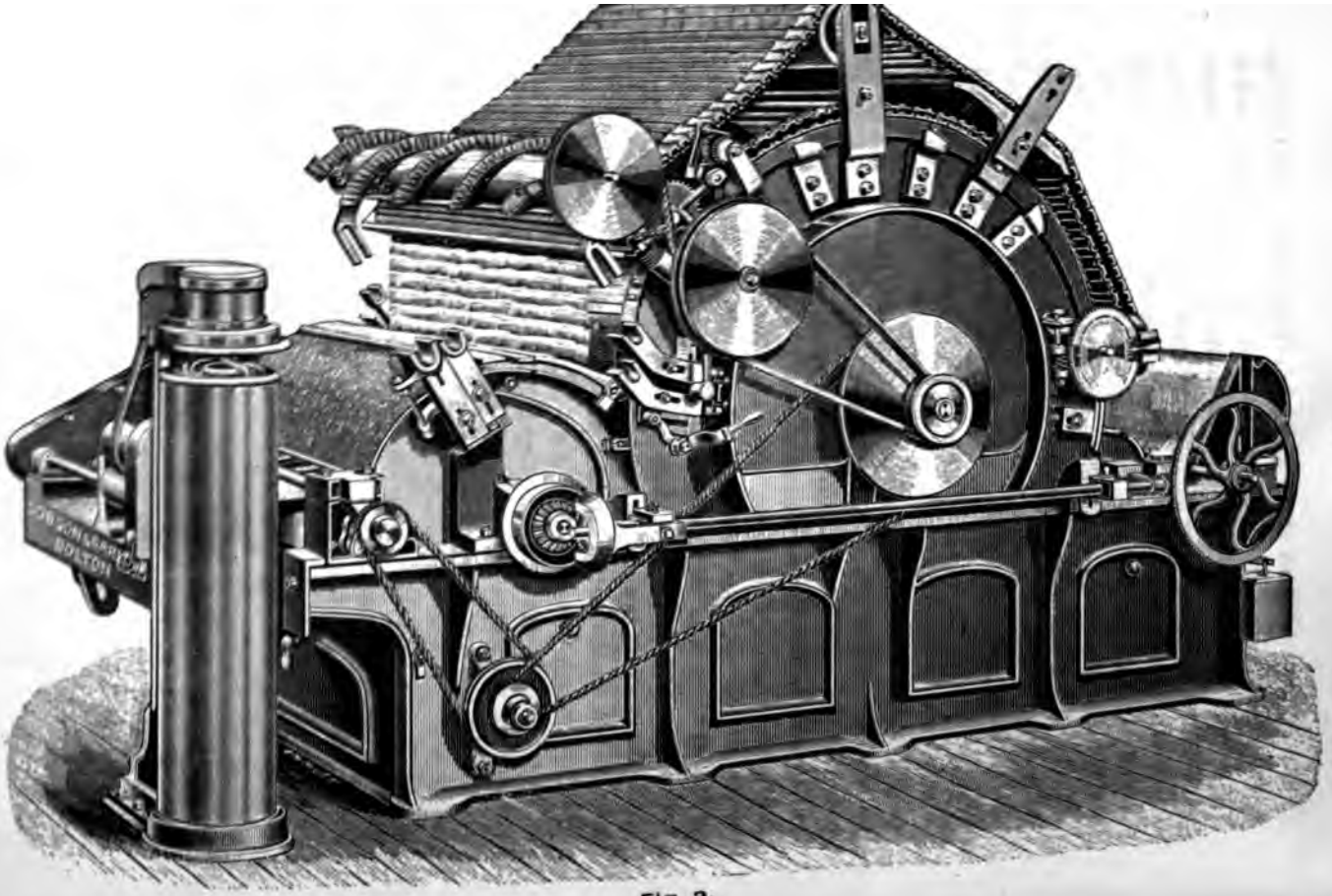


Fig. 2.

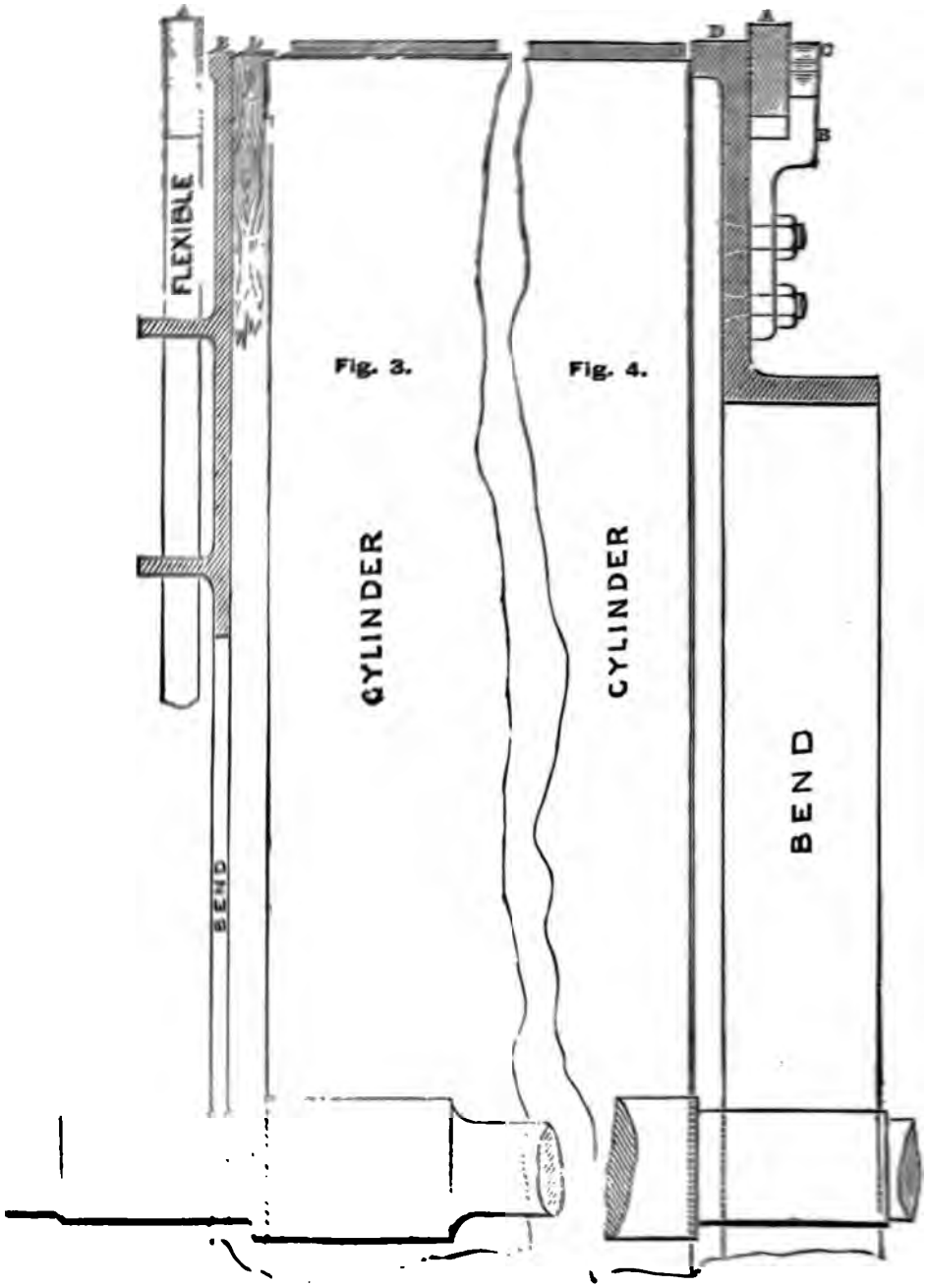
have got it quite accurate enough. This setting enables the head carder to set all his own cards in a very short time, and at any time by going around and examining the dials he knows exactly in what position his flexibles are; and in any form that he sets these cards, there is an arrangement by which he can put a padlock on, and lock the setting up so that nobody can tamper with it.

So much for the flexible bend. There are two other advantages which this card possesses over the ordinary system, which I want to bring forward; and one of them is, that a wider lap can be carded on this card than can be carded upon a card as ordinarily built. In other words, a card taking a floor-space of ten feet by six feet will card a wider lap than an ordinary card taking the same space. This is accomplished as follows: the ordinary way in which Dobson & Barlow (who build both styles of setting), and I believe most other makers, build their cards, is this: —

A, Fig. 3, is the flexible. *B* is the bend of the card. Then there is a wooden sweep, *C*, put in there about seven-eighths of an inch thick, and on the top of that is a sheet-iron piece, *D*, and the cylinder projects underneath this piece so as to prevent any draught of air.

Then the clothing comes within about an inch of the edge of that cylinder. There are three-eighths of an inch more beyond the wire than there is the portion going underneath the sheet iron. In other words, you do not come up to the edge of the cylinder with the wire; there is considerable spare room between the bend and the first wire of the clothing.

The other system which is adopted in building this new card is as follows: *A*, Fig. 4, represents the flexible. *B* represents one of the brackets. *C* represents that steel pin resting on the bracket, and *D* represents the bend of the card. They turn up this inside face of the bend, and polish it; they then bring their cylinder close up to this face, leaving just space enough to allow room for clearance; and in putting the clothing on, instead of having three-eighths or a quarter of an inch nearly, outside of the first wire, they cut the tail ends in such a way that


FLEXIBLE
BEND
Fig. 3.
CYLINDER
Fig. 4.
CYLINDER
BEND
A
B
C
D

the wire itself comes right out to the very edge of the cylinder. In this way they are able to card a wider lap upon this card than upon the old style, and to make better selvages. They can card, on a card taking a floor-space of 10 × 6, a lap 41½ in. wide; whereas, on the ordinary card, I believe the greatest width of lap is from 38 to 39 inches.

There is a gain which is well worth considering in the carding power of a card.

The third point which I wanted to bring out was the extra number of flats that they are enabled to put upon this card. They put on 110 flats; 44 of those are at work constantly. The largest number, I believe, on the ordinary style of card, has been 102 flats, with 39 constantly at work.

These flats are 1⅝ in. wide, and they each carry wire a full inch in width, which, I believe, is as much wire as is carried by the usual 1⅝ in. flat. It is considered by Dobson & Barlow, that, with any cotton of ordinary staple, the more flats they can get on a card, and the more lines of points they can have working at the same time, the better the results will be. They have filled mills with revolving flat cards with all widths of flats, — 2½ in., 2 in., 1¾ in., and 1⅝ in., — and they have made an exhaustive series of experiments on this matter of width. They have finally come down to 1⅝ in. as being the best.

These three points are the ones wherein they consider their cards superior: 1st, the automatic setting of the flexible bend, enabling the head carder to set it himself, and insuring concentricity at every point; 2d, the wider lap that can be carded on a machine taking the same floor-space; 3d, the extra number of flats.

There are one or two minor points I wish to bring up; and one is, that they cast the bend of the card and the cylinder pedestal all in one piece. They thus insure, that when that card is set up, and the cylinder put in, it will be where it ought to be. And furthermore, they mount the cylinder in phosphor-bronze bearings. They have tried various devices for making the cylinder pedestals adjustable, as I believe the Ashworth card is constructed. They built a large number of cards for

Ashworth Bros. Their experience has led them to prefer, on the whole, to make the main bearings throughout solid, and to put in them the very best kind of bushings obtainable. They found some objections to the other methods.

There are several other points about the card wire and the grinding of the card, which I will not trouble you with. The three principal ones are those that I have mentioned, — the setting of the flexible, the width of lap carded, and the extra number of flats.

Mr. BROWN. I would like to ask if the clothing on the cylinder is filleting, or whether it is in sheets.

Mr. ATKINSON. It is filleting.

Mr. BROWN. And do I understand you to say, that the result of Dobson & Barlow's experience is, that the more flats they can have at work, and the more lines of points they can have at work at the same time, the better the carding will be?

Mr. ATKINSON. Yes.

Mr. LEIGH. I have but a few words to say. I think what I said twelve months ago, that a flat an inch and five-eighths wide was as good, and would produce as much work, as a larger number of narrower flats, has been proved to be the case. Experiments have been tried on a large scale in England, with flats of different widths on the same cylinder; and they have settled down to a flat an inch and five-eighths wide as being, take it all around, the best.

As regards the different modes of setting, I told you that I had spent six weeks in looking at different cards, and, from my early connection with the business, I thought I was qualified to judge of what I saw in the different mills and works, and I told you I had selected one particular card, and gave you my reasons for doing so. Up to this day I have not seen a card that can beat it, and I have had trials in different places with all the cards that we hear spoken of. I also told you that there was a card with which they profess to card a thousand pounds a week — forty inches wide. Those cards (I am speaking of the Ashworth card) have been put into operation on a large scale, and it has been found that the weight had to be reduced

to six hundred pounds before they could get the desired quality. There are several mills which have been obliged to reduce the weight on their cards from a thousand pounds to six hundred a week. The Ashworth card is the most expensive card that is made, costing more than any of the others. Therefore I say, that what I gave you then as my views on the card question have proved to be true.

The mode of putting on the wire "straight," so as to card close to the edges, was first introduced by Ashworth; it has since been adopted by nearly all the other makers of cards, including Platts, who put the wire on in the same way. The advantage is, that you get a better selvage; the lap-guides turn the edges of the lap over about three-eighths of an inch, so that a forty-inch lap comes on to the taker-in thirty-nine and a quarter inches wide, and insures excellent selvages. Some parties make the lap forty-four inches wide for forty-inch cards, and turn the edges over two inches; this causes the edges to be double thickness, and can only result in bad work. By adopting the plan of putting the card clothing on "straight," you really get two inches more carding-surface, as a forty-inch lap can be made instead of thirty-eight inches.

About the mode of setting which has been described, I would simply say that the flexible bend, as my father left it thirty years ago, has not been beaten to this day. Various devices have been tried with pins and wedges to get a true circle, but the flexible bend, with all its apparent faults, is better in form, whether for new or old wire, than any other method of setting that has come up. With the flexible bend you can follow your cylinder, as *it is independent of the fixed bend;* but, if you attach your mode of adjustment to your fixed bend, you depend entirely upon your *cylinder keeping concentric* with it. Should your cylinder move from any cause, the accuracy of your adjustment is gone. Gentlemen who have been on the other side, and seen the flexible bends made and tested, will bear me out in saying that each bend put on these cards is tested from the largest to the smallest diameter required, and that they conform to a true circle at all points. But if these new modes of setting

to such improvements they might as show themselves in some way, either by producing more or better work. If they will not do more or better work, what do they amount to? The question is, can you get more than a day, of as good or better quality from a card with all this mechanism? If you cannot, then what is the good of it? It is what the card will do, year in and year out. It is not what the card will do for a day, or a month, but it is what it will do regularly, that we want to get at, and that will be the true test.

Mr. Edward W. Atkinson. I myself do not wish to dispute Mr. Leigh as to the respective merits of one and five-eighths as against one and three-eighths flats. I have not been to England and cannot speak with as much authority on that point as he can; I can simply say that Dobson & Barlow (I think you all know them by reputation as machine-makers) have built in the last eight years about eight thousand of the ordinary cards, set in the ordinary method with drag-screws. They have tried various experiments with all kinds of flats. Their representative has recently been to this country; and he states that their experience is, that an inch and three-eighths is a better width than an inch and five-eighths. These cards have not yet been fully tested in this country, but I say that is their experience, and they accept the results of that experience in building their machinery. They claim that if you get forty-four (44) flats on a cylinder, you get just so much more carding surface than if you have only thirty-nine or less.

As to this wear and tear of the card, the cylinder getting out of position, and all that sort of thing, that is liable to occur with the use of any card. They take special pains to make this card so that accidents shall not happen. They cast their cylinder pedestal in the same piece with the bend, and then they put in phosphor-bronze bearings, which have the best wear of any metal known. That flexible is capable of being moved. The curves upon those brackets are made sufficiently long to have the flexible capable of moving down to any extent, even if that cylinder does get out of centre; but there is no more possibility of that cylinder getting out of centre than there is on any other card.

Mr. LEIGH asked the question, Will this card do more work than an ordinary card? All I can say is this: that Dobson & Barlow have had numerous competitive tests with the ordinary style of card, with the drag-screw setting, and they think they have done very well in those competitive tests; and in such tests as have taken place on the other side of the water, parties who were ordering cards thought so well of this new card, that they were not only willing to place their orders for that card instead of the ordinary one, but to pay more for it. I do not think there has been any proof hitherto that this card will not do more work than the ordinary style. On the other hand, I think there has been proof that it will. I do not say that there has been any such proof in this country, but I can cite instances on the other side where there has been.

Mr. EDWARD ATKINSON. I do not like to intervene in the discussion of this question, because my name is already identified with it; I only want to make a few general remarks.

You may remember, that, on my return from England three or four years ago, I stated that the English carding-engine, whatever its merits might be as a carding-process, had been brought to a degree of mechanical perfection which was amazing and exceedingly interesting. In speaking of the various cards (in which I had no business interest then, and have none now), I said that the Hetheringtons had succeeded in making an adjustment of the most perfect kind, by grinding each separate cylinder to each particular bend or circle by which the top flats were to be guided after the card was set up, and that seemed to be the last point of mechanical perfection at that time. I then found, however, that there was a decided distinction in carding-engines as to the points of capacity and quality. Any one of the ordinary English carding-engines could do its requisite quantity exceedingly well; but they were beginning to discriminate with respect to the quality of the carding, especially with reference to the carding-engines that were to be used in connection with fine spinning. I then found that the Dobson & Barlow card was the one which was being adopted mainly in the fine mills, where the owners were look-

ing as much to quality as to quantity. I think the Hetherington's were then expecting to get ahead of them.

Mr. STILES. I was hoping the discussion would take a little different turn in regard to carding. I wanted to know, if possible, which kind of cards do the most and the best work, with the same outlay of money. That is to say, whether a thousand dollars invested in the English card would give us more pounds of the same quantity of cotton in a week than we could get from the same outlay in the American card. Also, what difference, if any, there was in the waste of the different styles of cards. If there is any gentleman present who can give us any information upon these points, I think it would be acceptable to the Association.

The PRESIDENT. The Board of Government took some pains to ascertain what could be laid before you in the way of such information as Mr. STILES requests; but the invariable response that they met to the question asked, was, that the experience had been too limited up to date to enable them to say any thing positive about it. There are, as you all know, a great many cards being put into mills in various parts of New England; and, in the course of another six months, I have no doubt but that some gentleman will be able to give you figures which will be interesting, and perhaps instructive.

Mr. EDWARD ATKINSON. With reference to rope-driving, I procured from the firm of Coombe, Barbour, & Coombe, in England, who do much of the work for rope-driving mills, a set of their pulleys for the use of the Institute. They are now in the basement, alongside of the grooved pulleys which are furnished by the Dickson Manufacturing Co. If you wish to see them, you can do so. I was told by Dr. Bowman that the art of rope-driving consisted wholly in the shape of the groove. It is in the bite of the V that the secret is said to lie, and that determines whether they will work well or work ill.

Mr. WALTER E. PARKER. I thought well of the suggestion which the President made a little while ago in regard to

the testing of yarn. I would like to see something done, with a view to securing uniformity in tests. I will make the motion that the matter be referred to the Board of Government to see what can be done.

The motion of Mr. PARKER was put and carried.

Mr. EDWARD ATKINSON. If any gentlemen desire to examine those grooved pulleys, Professor LANZA will explain the differences, I have no doubt. I think there is a difference between the pulleys in several respects, which may be of some interest.

Prof. LANZA. Some of the pulleys of the Dickson Manufacturing Co., which are in the laboratory, are merely guide-pulleys; so that if the gentlemen wish to see the shape of the grooves used by the Dickson Manufacturing Co., they must look at those which are intended for driving.

Mr. STILES. I understood some time since that Mr. PARKER of the Pacific Mills was putting in a new style of loom, and he hoped to have it in running order by the time of this meeting. If he has got it into running order, and has any thing to say for or against it, I would like to hear him.

Mr. PARKER. The loom I expected to have in operation before this time has not arrived. I cannot, therefore, say any thing about it.

There being no further business, the meeting adjourned.

NOTES ON MILL CONSTRUCTION.

By CHARLES T. MAIN, Lawrence, Mass.

PREFACE.

THIS paper was prepared for the use of the students in Mechanical Engineering at the Massachusetts Institute of Technology. It was not assumed to present any thing strikingly novel in mill-construction, but simply designed to put into convenient form those principles which it is necessary for the young engineer to know, and which would require considerable time in looking up from various sources.

SECTION I.

SITE. — Although the selection of a mill-site very rarely falls to the mill-engineer, yet a brief outline of the leading characteristics which tend to the selection of certain places for the erection of mills thereon, will hardly be out of place as an introduction of what is to follow later on, and which, to a large extent, depends upon the location selected.

A site is chosen from natural or artificial advantages, or a combination of both, offered towards the economical production of a certain class of goods, — on the stream or river, for the utilization of water-power to be obtained by improvements, such as dams, canals, etc.; at the tide-water, to take advantage of cheap rates for transportation of fuel and raw materials by water; at the railroad centre, where the competition on freight tariff is sharp; or near the base of supplies of raw material or fuel, in order to make the first cost low. At the present time, if one of these advantages is offered alone, it must be under the most flattering circumstances for success; while a combination

of two or more sets of advantages in nearly all cases is necessary to compete successfully with other mills running on very small margins of profit.

As the cost of power is a continuous and very important portion of the running expenses, it has been the first point studied in the selection of nearly all the existing sites. Water and coal are the two chief supplies for power, and nearly all of our great manufacturing cities and towns are located on the borders of a river where the water is utilized as motive-power in the mills.

The value of a water-privilege depends upon a variety of circumstances.

1st. On the abundance and uniformity of flow during the year, and for a succession of years. If the variation is slight, only the minimum flow can be utilized at all times; or, the average flow being used, there must be a portion of the machinery stopped during low water, which may be a source of inconvenience, and perhaps serious loss. If the variation is large, the water-plant must be supplemented by steam-power to make up the difference, and this necessitates the cost of two plants.

2d. The geological conditions which govern the expense of construction of dam, canals, etc., and the cost of construction of mills. These items will depend largely, also, upon proximity of an abundant supply of building-materials.

3d. Upon the requisites for perfect sanitation at hand, such as a good supply of pure water for domestic purposes, natural conditions to insure a good sewerage system, and upon the natural healthfulness of the location.

4th. Upon existing or planned railroad facilities.

The abundance of the water-supply depends upon the size of the river basin or area drained, the amount of rainfall, the nature of the soil, a larger portion of the rainfall reaching the river where the soil is impermeable, and the presence of forests which retard evaporation.

The uniformity of flow of river depends on the number and size of storage reservoirs, natural or artificial, which regulate the flow by storing up water in the wet season for use during the dry season, and by preventing sudden rises in times of fresh-

ets; on the nature of the soil, which, if permeable, absorbs the rainfall and gives it up gradually, and if impermeable, discharges the rainfall almost immediately; and upon the presence of forests and grass-lands, which retard the flow towards the river. The temperature or climate also affects the uniformity of discharge; for, while in a moderate climate the greatest flow may be during the winter months and the least flow during the summer, in a colder climate, or where the sources of rivers and the reservoirs are in very cold climates, the greatest flow would be during the summer and the least during the winter. A case of this latter sort is at Minneapolis; while the former occurs on the Merrimack River, at Manchester, Lowell, and Lawrence.

The St. Lawrence River, which is the outlet for the Great Lakes, is so constant in level that variation is scarcely noticeable. And the Merrimack River, with its large storage reservoirs at or near Winnepesaukee, is the largest manufacturing river in the world.

Before the final decision has been made, such information should be gathered, as possible, concerning the flow, by actual surveys and measurements, and such records as may be consulted. The surveys should be sufficiently extensive to determine pretty clearly the cost of construction of all river and canal work, to show the nature and lay of land for proposed mill-sites, and to prove that the location of the town is proper to fulfil such requirements as have been mentioned to insure a healthy population. This work properly comes under the head of hydraulic and civil engineering.

Locations of small mills and the utilization of smaller privileges do not require such an extensive set of surveys; yet as much information should be obtained, and surveys extensive enough made, to insure a proper understanding of the conditions, expense, and final results.

If the motive-power is to be steam, the site is to be chosen with special reference to cheap transportation of fuel and raw materials, and nearness to markets.

The necessary conditions for sanitation are still to be maintained as when the power is water; and the only additional

necessity is a sufficient supply of good water for boilers, and for washing and dyeing purposes, which in the former case was supposed to be obtained from the same source as the power.

Considering the necessity of a boiler-plant of some size, in a mill driven by water-power, for various heating-purposes, and the necessity of both water-wheels and engine where the variation in water-power is large, also the many uses to which exhaust-steam may be put for these same heating-purposes, and the possibility of obtaining power from this steam before using it for heating-purposes, at a very small per cent of the fuel used for its production, it would seem that in cases which are not extremely favorable for cheap water-rates, that steam-power would be as cheap or cheaper. Under the customs now in vogue in one of our most prominent manufacturing cities, steam-power can be produced cheaper than water-power, and the total cost for effective horse-power per year for steam, including running expenses, maintenance, depreciation on plant, etc., is less than the same expense of water-power.

The cost of steam-power in small amounts is greater than in large amounts, but for mills requiring five-hundred-horse power or more, as economical results can be obtained with steam as with water in almost every case. To this add the advantage of a uniform, steady power, independent of the rise and fall of a river, and the saving which this may mean, also consider the better results attained by steam-power, and we can plainly see why this statement is practically proved at Fall River and elsewhere; and there is no better proof than this that steam-mills can successfully compete with other mills driven by water-power.

The water-powers are nearly all utilized which are within the limit of distance from the markets and base of supplies. The compound engine has now become established as the best type of mill-engine, with high duties; and the various requirements for the use of steam can all be attained through special forms of this type of engine. Perhaps on account of the lack of water-power, steam has been used more generally than it would have been; but the future mill, of considerable size, can be run as economically with steam as with water.

PRINCIPLES OF CONSTRUCTION. — At whatever place the site is established, the principles of construction, excepting that portion of the work which belongs to the motive-power, remain the same, changing only in detail for different kind and quality of material to be manufactured, different circumstances of location, and the natural resources of building-material.

A mill is designed for the manufacture of a certain class or grade of goods, is proportioned to receive the machinery and operations necessary for the production of such goods, and for the protection of such machinery and goods. The two principal objects in view in the arrangement of machinery and construction of mills are: 1st, *Economical production of finished goods;* 2d, *Stability of the structures.* These are the fundamental principles of mill-engineering, and all other conditions are subservient to them.

GENERAL ARRANGEMENT. — To obtain the first, economy of production, the arrangement of buildings and machinery must be such as will make the various processes through which the material passes follow one after the other, in direct succession, with no "backing and filling," but in a continuous journey from the raw material to the finished goods. Sufficient space should be allowed for convenient working, but no amount of useless space, which only increases the first cost, and expense of maintenance. Due regard, however, must be paid to the probable needs of the near future. The general arrangement will vary with each individual case; but as far as possible it will be well to have the delivery and shipment concentrated as much as possible, in large concerns the journey being from the store-room for raw materials to the store or shipping room for finished goods, the journey forming a rectangle. In many cases this shape would be impossible, and the journey might be in an approximately straight line, receiving at one end and delivering at the other. In all cases the simplicity of the arrangement is the measure of its efficiency.

ORDINARY PROPORTIONS. — The general proportions of an ordinary cotton-mill, for economy of space and work, will have the spacing between columns, and between columns and walls,

about 23 feet, or a total inside width of about 46, 69, and 92 feet, or outside widths of 50, 73, and 96 feet. Some engineers make outside widths of 50, 75, and 100 feet, which affords a little more space in the alleys. The width of bays, or distance between columns lengthwise of mill, is about 10 feet. The height of stories, for good light and convenience of shafting and belting, should be about 12, 13, and 14 feet for the respective widths. A mill 73 feet wide and 13-feet stories is very nicely proportioned: 12-feet stories brings the driving-belts rather low, and too low for comfort for any thing below 12 feet. In the other extreme, 16-feet stories, the belts and shafting are out of convenient reach. Where there are several mills together, a uniform height and grade should be established as common for all widths, so that bridges may be carried across from one to another on a level. The number of stories and length of mill will vary with the space allotted; but it is pretty generally conceded, that, for a large mill, a four-story mill is the most economical, every thing considered. The old style of high and narrow mills has gone out of use. The particular advantages of the one-story mill are, less vibration, which is conducive to better work, and more light, which tends towards the same end. If the weaving be placed in a separate building, one story preferable for colored work, the preparatory machinery may be by itself, and better work will be done. With such arrangements as this, the one-story will show no particular advantage over a four-story mill, and the cost of construction per square foot of floor-space is more for one than for four stories. This statement is based on what mills have actually cost, and not upon estimates of what they would cost.

Next in importance to the arrangement of machinery and buildings, and closely connected with it, is the arrangement and working of the motive-power, and the distribution of power, especially where power is expensive. If water-power be used where there is an abundance of water at very low cost, the question of economy does not enter into the consideration; the first cost of plant, and maintenance of the same, being the important items. When the supply is limited and the rates high,

the most efficient turbines are to be used, and the power distributed in the simplest and most economical way. If the power be steam, and the fuel coal at high cost, the most economical plant of boilers and engines should be used, with the distribution of power the same as before. The economical distribution of power is, to a great extent, dependent upon the stability of construction.

STABILITY OF CONSTRUCTION. — The stability of construction includes protection against any reasonable loading of floors, pillars, or walls; deterioration of mill caused by constant jarring and vibration; too rapid deterioration from ordinary effects of exposure to atmosphere, wind, and weather; disasters in case of fire; and prevention of fire. These are the chief points of construction, and will be considered in their proper places. The greater the risks run, the greater should be the pains taken and margins of safety.

Architectural beauty is the last consideration, but yet may be obtained at no increase of expense, if we consider beauty in architecture as it really is — the adaptation of each part to symmetrically form the whole structure, and the adaptation of the whole structure to the purposes required. If we fulfil the two fundamental principles stated above, *adaptability* and *stability*, we shall have true architectural beauty. Beauty in architecture impresses itself on us with a feeling of satisfaction, inasmuch as we realize the fitness of the means to the end. The impressions of strength and stability should be characteristic of a mill building. There should be nothing shown apparently useless, and true decoration shows nothing which is not useful; it is simply a higher finish of useful parts. There should be a similarity of portions used for the same purpose, and symmetry in the assemblage of these parts. There is no addition in expense incurred in putting material together in such a manner as to make the best of every thing, while the same amount can be spent in putting it together awkwardly. We may combine utility, strength, and economy, with taste and judgment, and obtain a result which will be pleasing, and fill us with that feeling of satisfaction which we have attributed to beauty.

SECTION II.

FOUNDATIONS.

THE most important, and at the same time most difficult, portion of a building is its foundation; on the strength of this depends the whole superstructure. Settlements, if great, are disastrous, and often incur great expense in repairs, or, if it is impossible to repair them, necessitate the tearing-down of the building. If small, they are sometimes very troublesome, causing great annoyance as well as adding to the running-expense of shafting and machinery, and increasing repairs on the same. Very careful attention must be given to this portion of the work. There is often a chance for a saving here, but it should not be done where there is the slightest doubt as to the feasibility, and an extra dollar spent may result in the saving of many dollars later on.

If not already familiar with the geological conditions of the proposed site, from existing structures, wells, etc., the first thing to be done is to become familiar with them by boring, sounding, or sinking test-pits. It is hardly safe to depend upon a knowledge of the soil in close proximity to the site; for, at the Lower Pacific Mills, in the same yard there are soils varying from a bog-hole to extremely hard-pan and ledge, and under one building is ledge and hard-pan; under another, hard-pan and sand; under another, hard-pan and a bog; and under still another, sand, which, if not confined, will flow with water like molasses.

Borings may be made in soils which are not hard and stony, with a common wood-auger welded on to a rod, which is usually made in sections, to be screwed together for deep soundings. A handle or lever is clamped to the rod, and turned by two or four men. Very fair samples of the nature of the soil can be brought up to the surface by pulling up the auger, but these samples do not show the consistency of the soil, which has been ground up by the auger; this must be judged by the resistance offered and the nature of the soil shown.

In very hard and compact earth, soundings may be made, but no samples brought up, by connecting a drill-point, as shown in section in Fig. 1, to a ¾-inch gaspipe, to which is connected a rubber hose which supplies water to the drill under pressure. The pressure being let on, the drill is jumped up and down and turned around by the handle, and, by this pushing and drilling, the rod sinks; the condition of hardness being judged by the rapidity with which the drill sinks.

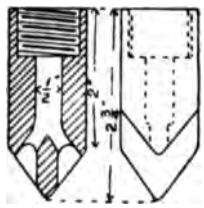


Fig. 1.

This method is used successfully when testing for ledges. If testing simply for firm foundations at short distances, a plain rod may be driven down, and, as before, the degree of hardness is indicated, but not the character of the soil.

The most satisfactory way to ascertain the nature and consistency of the strata is to sink trial pits as frequently as deemed necessary. If these are too expensive, they may be sunk to the grade of the bottom of the foundation, and the test below this grade made by sinking rods for a depth of six to eight feet below.

Having ascertained the condition of the soil, the maximum pressure to which it is to be subjected is decided upon, and from estimated loads the widths of foundations are determined.

Solid ledge, of course, forms the securest foundation, provided it goes around the entire building. Part ledge and part earth cause unequal settlements, which are the more unequal in inverse proportion to the firmness of the soil. The ledge, if uneven, must be bevelled off, and, if on a slope, cut to form steps to give horizontal surfaces. All hollows should be filled with concrete or stone laid in cement mortar; and, on shaky rock, concrete is spread at unequal depths to distribute the pressure evenly. In going from rock to earth foundation, the footing-courses should be spread out to a greater width on the soil next to the ledge, gradually narrowing in to the regular width for earth foundations. Should there be any unequal settlement, it is in this way spread over a greater length of brickwork, and perhaps thus save cracking in the walls, which might otherwise occur at the junction of earth and rock.

Hard gravel, or hard-pan, is quite as desirable as ledge, making a very firm foundation: gravel and sand are also good when kept dry. When the loads are extremely heavy, it is well to pound the gravel down, if not already compact, before laying the stone or other material. A stratum of six to eight feet, even if underlaid by softer material, is usually safe; but it may sometimes, in a case of this sort, be advisable to widen out the trench and fill it with broken stone rolled down, or a layer of concrete, which is much better.

Clayey soils, which at first sight might seem to be a very nice foundation, are usually treacherous: upon exposure to the air they dry and crack, and, exposed to rain, become semi-fluid or expand. If this soil must be used to build upon, it is better to open only a small portion of the trench at a time, and quickly fill in behind.

Where there is an unreliable soil, piling must be resorted to. If firm earth cannot be reached by the bottom of the piles, the supporting force is friction alone, and is small. If there be an underlying firm stratum, but at such a depth that excavation would be too expensive, and sometimes impossible, — and foundations carried to such depths would cost enormously, — still within the reach of piles, then piling can be used with good success, giving a good or fair bearing.

Sand and silt, when dry and confined, form a firm foundation, but when mixed with water and allowed to run, becoming in this condition quicksand, is the worst of all foundations. When there is water present, the expense of excavation is increased, making it necessary to work on separate portions at a time, enclosed in a tight crib.

The proper weight per square foot to be supported will vary in proportion to the firmness of the soil, the width of the footing-course varying inversely as the firmness of the soil. On clay the pressure should never exceed one ton per square foot; compact sand and gravel, one to two tons per square foot; hard-pan, two to three tons, and occasionally, under extremely favorable circumstances of soil and use of building, four tons, per square foot.

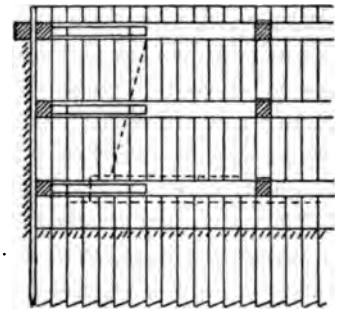
In the same building, with a uniform firmness of earth under it, the area of foundations for towers, cross-walls, and piers shall be in the same proportion for pressure sustained as the outside walls; and in case the soil should vary considerably in one portion from another, the areas supporting equal weights should be changed to correspond to the soil. In this way unequal settlements are avoided, and the most economical structure of approximately uniform strength obtained.

Work on foundations consists of excavation of earth or rock, including shoring, sheet-piling, or coffer-dams, and a structure at the bottom of the excavation of stone, concrete, brick, or timber, including bearing-piles. The expense of excavation will increase with the hardness of soil and inconvenience for working, in nearly all cases; but if the excavation is in sand or soft earth, with considerable water to contend with, then the cost is largely increased by the necessary structures for enclosing the excavations and sustaining the banks.

Earth is hard in proportion to the amount of cementing material which it contains, and its temporary stability depends on the same thing, while its permanent stability depends upon the friction of the particles on each other. The disadvantage of hardness for excavation is offset in many cases by the advantage of the self-sustaining power of the vertical cut, for a time sufficient to do the work in the foundation. If a vertical cut is exposed for a long time to the weather, it may become dangerous. The effect of moisture, freezing, and thawing, is to crack off the bank, and gradually to approach the natural slope, or that of permanent stability. If the time required to lay the foundation be very long, or the weather unfavorable, it may become necessary to shore up even in firm earths, but in a much less expensive manner than in material which has a tendency to flow.

In working in clean sand or gravel below a depth of five to six feet, shoring may be done as stated above, by laying in planks horizontally along the sides of the banks, putting in vertical timbers or planks at short intervals, opposite each other, and bracing between them. Even with this sort of shoring it is well to make it secure, so that no braces or other pieces may

drop out and injure some person, and perhaps cause a slide. When we get into sand containing water, or soft clay with running water, the saving of soft excavation is entirely absorbed and sunk out of sight by the expense incurred in sustaining the banks, and preventing damage to adjacent buildings, if there be any. Sheet-piling must be used here, which consists of planks or timbers driven closely together, of a thickness varying from two-inch plank up to whole timbers, according to the depth, pressure, and soil. Four-inch plank is about the thickest used in ordinary mill-work. Three to six inch plank should be grooved on edges, the grooves to be filled with splines. The usual way for driving sheet-piling is to lay out the line for the sheet, and on the line drive some guide-piles, the excavation being carried down as far as possible before commencing to drive. To the guide-piles are bolted or spiked stringers or rangers, inside and outside, which serve as guides for the piles at the top: a second ranger on the inside serves as a guide, while the soil presses the pile from the outside. The bottoms of the piles are tapered off, and also cut slanting, so that there will be a tendency to crowd against the next one already driven. The tops should be protected with an iron ring to prevent splitting while driving. These are driven far enough below the grade of the bottom of foundation so that no outward pressure can break them below the bottom ranger. As the excavation is carried down, these rangers are put in at a distance of five or six feet apart, and the bracing from side to side done on them. Although this is only a temporary struc-



Section A-B.

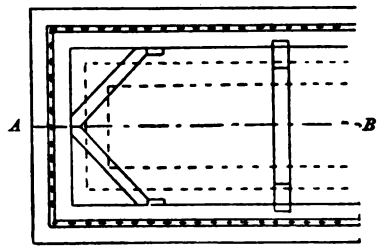


Fig. 2.

ture, all the piles should be new and sound, as they are subjected to severe strain while being driven, and can be used again elsewhere if extracted, while shaky timber would cause trouble and perhaps cripple the sheeting, and would be useless after extraction. Fig. 2 will give an idea of a double row of sheet-piling for a foundation of an outside wall.

Where there is any large amount of sheet-piling done, the ordinary pile-driver with which you are most familiar, where a weight is drawn up and dropped, worked by steam, is the best way to drive the piles. The ram should be lighter than for driving bearing-piles. Where the work is not very large, they may be driven with heavy beetles or malls, but this method is extremely slow for thick sheeting. A good many light blows of the ram when driving by steam is better than a few heavy ones, and is not so apt to cripple the planks. It is customary to cut the trench around for the outside walls, leaving the earth which comes inside the building for the support of the sheeting until the walls are built and set enough to receive the outside pressure.

COFFER-DAMS. — Coffer-dams are built for the exclusion of water while work is being done. The kind employed depends upon the nature and extent of work to be done, and the strength should be somewhat in proportion to the amount of damage or delay from failure. As the space and amount of puddling material are usually limited in mill-work, the best and usual form will be a bank of puddle enclosed and supported by a row of sheet-piling on each side, as shown in Fig. 3. Experience has shown that four to six feet is sufficient for the puddle to exclude the water;

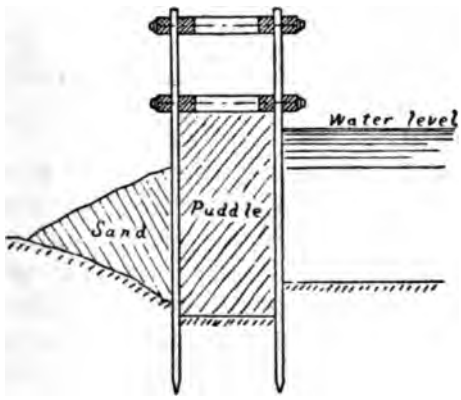


Fig. 3.

but unless the dam is supported independent of itself, the width must be in proportion to the depth of water, so that it will not be overturned. Good timber should be used here as in ordinary sheet-piling, for the same reasons. Where there is room, a bank of sand against the inside sheeting will assist in supporting the dam.

Single-sheeted dams are sometimes used successfully. They are made from planks, tongued and grooved, or carefully caulked, but they can only be used successfully where the soil is not of a flowing nature; for if it is, when the pressure is relieved from the inside, the flow will start under the bottoms of the piles, and render the dam useless. This sort of dam should never be trusted where the damage would be great, or delay expensive, if it gave way. The extra cost of a double dam will, in nearly all cases, pay for itself.

MATERIALS. — The disposal of the material of excavation should be made in the cheapest and quickest manner. If by carts, and the inclination is not too great, a run should be made from the surface to the bottom of the excavation, and the carts backed down and filled. If by wheelbarrows, the run should be the same. If loaded into cars, on a side track, the material may be hoisted by derricks, steam-power preferred, in scales, and dumped into the cars. If it is impossible to load carts in the excavation itself, they may be loaded in the same manner as the cars. In excavating the trenches in soft material, the hoisting method must be used.

Material to be used again for back-filling should be put in a convenient place, and back-filling should be begun as soon as possible, to protect the foundation from the weather and for convenience in working.

COST. — Excavations of earth, where no shoring is required, can be done, at present prices for labor, for thirty cents per cubic yard in soft material, to fifty cents for hard material, measurements to be taken before and after excavation. This is the proper way to estimate the amount taken out; and, if done so, may save a good deal of controversy between the contractor and owner or company. Where the excavation is very troublesome,

the expense will be greater. Rock excavations will cost from fifty cents to one dollar per cubic yard, according to the hardness, accessibility, etc. If the rocks are sound, with good beds, they may be used in the foundations.

STRUCTURES. — Of the structures at the bottom of the excavation there are many forms and kinds. Those most commonly used are: stone laid in cement mortar or bedded work; stone laid with outside joints pointed, and then grouted full; stones laid dry; and combinations of stone, concrete, and brick.

We will dispose of the type of dry work very quickly, as unfit for mill-work. As there is a constant vibration, the few bearing-points of the stone, when laid dry, will get worn off, and thus cause slight settlements, which, though perhaps not unsafe, would cause annoying cracks.

Stone laid in cement mortar, with bedded joints, is the surest kind of stonework. With grouted work there is not that surety of filling all the joints. Grout, when made thin enough to run freely, takes a very long time to set and strengthen, and never attains the strength of cement mortar. The sand is also liable to settle away from the cement, thus making the final strength variable. Old foundations laid dry may be greatly strengthened by pouring in grout, and pinning them up.

Whichever of the two above walls are built, the method of laying in the stone is the same. All stone should be laid on their natural beds to obtain the greatest strength, the largest stones being used for the footing-courses. In order to distribute the pressure over several stones, and to tie the wall together, they should be laid to break joints, having no two adjacent vertical joints in the same vertical plane. The trench must be prepared to receive the footing-course, and a bed of mortar should be spread before the stone is finally lowered. Not the slightest rocking motion should be allowed. Every stone should be washed clean, and this washing will moisten the stone so that the moisture will not be absorbed from the mortar. Joints should all be filled, and care taken that they are as small as possible, not more than one-sixth of the whole contents being mortar. In stepping back, make the lap so small that there is no

danger of cracking off the courses below. The outside must be laid up as smooth as the inside if a water-tight wall is expected. If the outside is rough, water will work into the interior, causing the entire mass to disintegrate. Fig. 4 shows a section of wall laid in cement or grouted.

In many cases, brick is used above the footing-courses for foundations. Bricks for this purpose should be hard burned, and should be closely laid, and great care taken that all joints are filled. The bricks should be clean and wet before laying, and the cement mortar a little thinner than usual. Before back-filling, the outside is covered with two coats of hot tar, which will make it almost impervious to water. There is an advantage of a smoother wall for basement stories than those with stone. Fig. 5 shows a section of this form of wall.

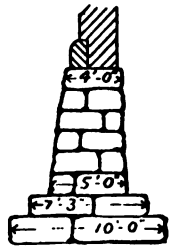


Fig. 4.

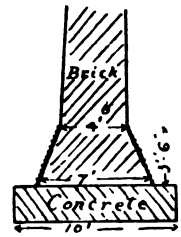


Fig. 5.

It is almost impossible sometimes to get large stone down and laid in a deep trench which is shored very much. In a case like this, concrete, which is one of the best materials for foundations, can be used. It is quickly prepared, can be easily handled, and will set where there is water. A combination wall of brick and concrete, as shown in Fig. 5, can be built without the use of derricks, or other hoisting machinery, and may save much time and expense.

The qualifications and proportions for good concrete are: 5 barrels of clean broken stone, of sizes from ½ to 4 inches on any edge, 2 barrels of clean, sharp sand, and 1 barrel of good fresh American cement, thoroughly mixed until all the surfaces of the stones are covered. It is dumped into place, and rammed

in until the cement flushes to the top and covers the mass. If there be water present, the concrete should be dumped into one corner first, and gradually spread along, driving the water before it. Should it be necessary to drain the water across the bed, a trench may be left through it, which afterwards can be filled with a mixture richer in cement. This will prevent the water from percolating through the whole bed. If water must be carried off continually, a pipe should be built into the wall. After depositing the concrete it should be disturbed as little as possible.

The foundation for house and engine recently erected at the Lower Pacific Mills rested entirely on sand where there was considerable water; and, when started, this ran like molasses. Cribs of sheet-piling were sunk to about 5 feet below the bottom of the foundation. These were about 15 to 20 feet square. The material was excavated in these cribs, and then a layer of concrete, 3 feet thick, deposited. Under the whole building and engine foundation is one sheet of concrete, 3 feet thick, spreading over an area of about 50 × 80 feet No settlement, beyond a slight shrinkage of half an inch, which is always to be expected, has occurred. The total weight of engine and foundation, excluding building and its foundation, is about 2,200 tons.

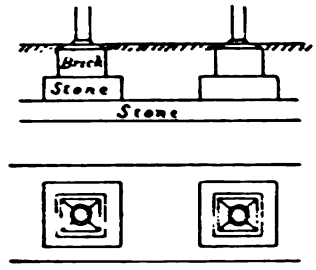


Fig. 6.

The cement mortar for the brickwork should be of the proportions one and a half sand to one of cement, for good brands of American cement.

Foundations for piers which support columns are subject to more shock than those of the side walls. They should always be built, unless on ledge, with the footing-courses continuous, running the entire length of the building, in order to distribute the weight over a greater surface, and to prevent any chance for soil to squeeze up between the piers, as it might do were they isolated. This method is shown in Fig. 6.

The footing-courses may be either stone or concrete. Inverted arches are sometimes turned between the piers; but it is scarcely ever necessary, and it is very much more expensive. I have a mill in mind which is four stories high, and used entirely for weaving, which of course brings the severest strain upon a building. It is fifty feet wide outside, and has one row of columns through the centre. These columns are supported by piers which rest on stones, one for each pier, about five feet square, or covering an area of twenty-five square feet. The pressure at the bottom is about one ton per square foot. The soil is dry river-sand, and at any time would be calculated to sustain the pressure put upon it. These piers settled soon after the construction of the building, and starting the looms from four to six inches, caused by the constant jarring. If the bottom course had been five feet wide, and continuous, this would not have happened.

It is always better to carry the foundation down to a bearing stratum; but when the stratum lies at such a depth that it would be exceedingly expensive, and perhaps impossible, to do the excavation, and the cost of foundations would be very great, piling must be resorted to. Piles are from ten to eighteen inches in diameter, usually of white pine and spruce for ordinary soils. They should be straight, and free from knots, cracks, and other defects. In stony soil it will be better to protect the feet by cast or wrought iron shoes, and in all cases it is necessary to protect the top from splitting by rings or plates. A broken pile should be removed, or another driven close to it. The earth around the tops being excavated, concrete may be filled in to stay and tie the piles together, and form a good base for the foundation. Piles must be cut off below the level at which water stands in the ground.

There are several empirical rules for determining the safe load to be supported by each pile; and the one most frequently used, perhaps, is Saunders's. For a safe load on a wooden pile driven until it sinks very little, and equal amounts for successive blows, $L = \frac{FW}{8S}$, where L = safe load in pounds, F = fall of

hammer in inches, $W =$ weight of hammer in pounds, $S =$ small sinking of pile in inches.

Trautwine gives another rule, which gives about the same results as Saunders's. $L' = \frac{\sqrt[3]{F} \times W \times .023}{S + 1}$, where $L' =$ extreme load in tons; F, S, and W same as above. For safe load divide by 2. $\frac{L'}{2}$ in Trautwine's rule is very nearly $\frac{L}{2000}$ in Saunders's.

For mill-work, on account of the constant vibration and tremor, it would be safer to divide L' by 4, and L by 2 for the safe loads.

Brickwork for piers should be laid of good hard-burnt brick in fresh mortar, of the proportions of one part good American cement to one and one-half parts clean, sharp sand, all laid flatwise, with close joints, and covered with a cap of stone or cast iron, which will answer for a tie on the brickwork, and also distribute the load supported by the pillar. The pressure on these piers, and on other brickwork laid in cement, should not exceed ten tons per square foot, although in some instances this is exceeded without serious results. The area should be greater for a high pier than a low one, in order to resist any bending tendency which may be brought to bear against it by lateral pressure.

In an old mill which has lately been remodelled, the piers consisted of small stones, approximately flat, of areas varying from twelve to twenty square feet, bedded in a thin layer of mortar: on these were built piers of brick one foot square, from one to two feet high, which were covered with a very thin cast-iron cap. On this cap the entire weight of six floors and roof was resting, aggregating about thirty-five tons to a pier. The earth below was sand. Although no disaster occurred, yet the floors were out of level from two to six, and in one place even eight inches.

In another case, where a mill has been added to in height twice, the weight of these floors and roof, amounting to about seventeen tons in some places and twenty-five in others, was

sustained on a square foot of brickwork. In this case there was no perceivable settlement. The piers below were broadened out, and covered about thirty square feet.

The cost of foundations of ordinary ledge-stone, random sizes, laid in cement mortar or grouted, would average about eight dollars per cubic yard, with a favorable chance for working. If the footing-courses are of large granite stones, of dimensions as follows, length six to ten feet, widths and heights eighteen to twenty-four inches, and the remainder of the wall of smaller stock, say four to six feet long, all laid in cement mortar, the cost would be about twenty dollars per cubic yard.

The weight of such foundations would be about one hundred fifty-five pounds per cubic foot for common ledge-stone, where the proportion of mortar is about one-fifth, and about one hundred sixty pounds for dimension stone, with one-seventh the whole contents mortar.

Concrete for foundations, as described above, will cost about five dollars per cubic yard, and for every cubic yard there is required about seven barrels of broken stone, three barrels of sand, and one and one-half barrels of cement. The weight is about one hundred fifty pounds per cubic foot.

The crushing strength of concrete increases with age. Trautwine gives, for concretes well made and rammed, of American cements: —

Age in months,	1	3	6	9	12
Tons per square foot,	4	10	16	21	25

As the transverse strength of concrete is small, care must be taken that the bed shall not lap far enough beyond the next course above to cause cracking.

As more cement is used in the foundations and piers than elsewhere, it may be well to note here, briefly, the most important points regarding its use.

A very extended series of experiments, which give a large amount of valuable information, were made for the main drainage works of Boston, under the direction of Mr. E. C. Clarke,

assistant engineer in charge of the works; and many of the conclusions arrived at are here given in condensed form: —

"While color and weight by themselves indicated little, yet considered together, and also in connection with fineness, they enabled the inspector to guess at the character of a cement, and suggested reasons for high or low breaking. A cement which was light in color and weight, and also coarse grained, would be viewed with suspicion."

The fineness of cement indicates the actual amount of cementing material it contains. It was found that that portion which remained in a sieve of cto. 120, or with a mesh of about $\frac{1}{100}$ inch square, was not much better than so much good sharp sand. This has an important bearing upon the amount of sand which should be mixed with the cement in proportion to a barrel of cement. It will sometimes pay well to give a little more per barrel in order to have the fineness increased to a high per cent.

Tests made of mortar are preferred to that of neat cement, as showing the strength under actual working conditions. The larger the proportion of sand used, the more accurately the cementing quality of the cement was shown; but owing to the time required for setting, and liability to injury of weak mortar, the proportion of three of sand to one of Portland, and one and one-half to two of sand to one of Rosendale, was used in the tests.

The amount of water used affects the strength. The amounts giving the best results were about 20 to 25 per cent for Portland, and 30 to 35 per cent for Rosendale. The difference in strength caused by different amounts of water, diminish with age, and thin grouts finally attain considerable strength.

The length of time for cement to set is determined by the "wire test." It has begun to set when it will bear a wire one-twelfth inch in diameter, loaded with one-fourth pound weight, and has entirely set when it will sustain a wire one twenty-fourth inch in diameter, loaded with one pound weight. There is no direct relation between the time of setting and the permanent strength. Slow and quick setting cements may be mixed together, to produce one that will set in any desired period of time.

In testing a well-known American cement, a twenty-four hour test was made, and for Portland seven days. An untried brand should have at least a month's trial, or longer if possible.

In mill-work the usual cements used are the American, known under the general name of Rosendale. Imported Portland cements are used only in special cases, where heavy loads must be supported in a very short time after use, and in places where there is trouble from water. Portland acquires its strength quicker than Rosendale, and rich mortars sooner than weaker ones, which continue to harden for a year or more. This shows the advantage of waiting as long as possible before loading the masonry structures, and the possibility, in a few cases, of saving cost by using weak mortars. The spirit of economy is a good one, but must not be carried to extremes.

For mill-work it is best to order those well-known brands which can be relied upon as being pretty constant in their qualities, and to make such inspection as can quickly be done, and those quick tests mentioned above; for in many cases the cement arrives on the ground at the very time when it is needed for the work.

Foundations for chimneys and other isolated structures, where there is a small base and heavy pressures, should be carried to the lowest depth to which it will be necessary to go with any other work reasonably near it. In sand there is a liability of undermining it, even if the new excavation is at some distance.

SECTION III.

Brickwork and Stonework above Foundations.

The two fundamental principles of brick walling are: 1st, The wall shall be as strong as possible in the direction of its length. 2d, It shall be so connected in its transverse direction that there shall be no possibility of its separating into several thicknesses.

A wall is strongest with regard to frictional resistance longi-

tudinally when all the courses are laid stretchers, and is strongest transversely when all the courses are laid headers, and is strongest in both directions at the same time when two courses are laid stretchers to one of headers. The old English bond, consisting of each alternate course headers and stretchers, makes a very strong wall. The Flemish bond, in which every other brick in the same course is a header, gives a very neat appearance, but is considered not as strong as the English. In the Flemish bond the joints must be kept plumb over each other, and in either case the bricks should lap so that no two joints in adjacent courses shall come in line. The bond most commonly used in mill-work is one heading-course for every fifth or seventh course, which gives a large amount of strength longitudinally and a sufficient amount transversely.

Too close attention cannot be given to this work. It is necessary for substantial and good-looking work to observe the following rules: 1st, To inspect the brick and cull out those of the best color and most perfect for outside work, and of the remainder for inside work to reject all unburnt or unsound brick, and those which are badly misshapen; 2d, To lay the brick with the beds horizontal or very nearly so, and to make joints by lapping the bricks one-quarter or one-half the length of a brick, according to whether it laps into a header or stretcher; 3d, To have the bricks clean, and in dry or warm weather to wet them before laying, so that they will not absorb the moisture from the mortar and cause it to crumble. To this end they should either be washed down with a hose, or each man should be supplied with a bucket of water, and should be obliged to dip each brick in before laying, and in extremely hot weather both wettings may be beneficial. The brick, however, should not be soaked with water, for in this case it is impossible to keep them in place before they dry out. 4th, That all joints shall be thoroughly filled with good rich mortar made from good lime, sharp, clean sand, and fresh cement, in about the following proportions: 4 barrels of sand, 1 barrel of lime, and ½ barrel of cement. The joints not to exceed ¼ inch in thickness, and the proportion of mortar to whole contents will be about one-fifth. 5th, To lay

no bricks in weather when the mortar will freeze and thaw before getting set. The work is weakened very much in this way, as the outside thaws when the sun strikes it, while the inside remains hard, which tends to overthrow the wall. If the mortar freezes and remains frozen until set, the work is not much weakened.

The walls should be carried up together, as nearly as possible, all around, and at no time except in extreme cases should one portion be more than a story higher than the rest. It is sometimes necessary to have one portion many stories above the rest, or to entirely build one portion of the building before starting another portion. In these cases the portion built first may have settled nearly to its permanent bearings before the second portion is commenced. It will be impossible to join the old and new work then properly, and each portion should be toothed out, leaving a smaller section between the window-jambs on a plain mill, or between the piers in a pilaster mill, to be filled in after the newer portion has settled to its bearings. When new portions are added to old buildings, this settling has a tendency to tear the new work away from the old. In a case like this, if the floors and windows are to be on the same level as in the old portion, they must be set enough higher to allow for settlement.

When laid well and at an ordinary rate, brickwork will settle about one inch in fifty or sixty feet. If run up rapidly, the settlement will be greater, in some instances to double that amount, depending to a great extent upon the thickness of the joints, and the weather. Due allowance must be made for these. If it is necessary to have the floors level, an allowance must be made for the shrinkage of the walls, while the columns maintain their length, or very nearly so, by pitching the floor-timbers up towards the walls so that they will come down level eventually. For ordinary heights of stories the allowance would not be far from a quater of an inch for second floor, and an additional quarter for each floor on the way up.

Hollow or vaulted walls, except for fire-walls, are very rarely used in mill construction at present. They diminish the strength with no apparent benefit.

As the height increases, the weight supported diminishes, and also the thickness of the walls, usually by dropping off a course of brick at the under side of the floor-plank. If the offsets were made on the outside, the building would be slightly stiffer. Sometimes the outside of the wall is battered, but the most satisfactory manner is to have a plumb face on the outside.

Cornices and covings should be laid closer than the rest of the wall, and the mortar should contain more cement.

All arches must be laid with close joints, or the shrinkage will cause cracks, and perhaps the arch will drop out. Very flat arches are hard to keep in place, and some buildings which are otherwise sound will have all the inside arches cracked by laying them with thick joints and making them too flat. A good rule for inside arches for doors, etc., with no great pressure to support, is to make the rise one-sixth the span of the arch.

There are two bonds for brick arches, called the "row-lock" and "bonded." In the first the rings are turned each independent of the one above or below. In the other the rings are bonded together as in a wall, usually one header and then a stretcher. Unless the mortar is as strong as the brick, the latter arch will be the stronger, but it is harder to lay, and in nearly all mill-work the "row-lock" arches are used and answer all purposes. Large arches for special purposes are laid in cement mortar, and should be figured for strength and size.

As much depends on the centre, or structure which supports the arch during construction, as on the method of laying. It should be strong enough to resist such unequal loading as may come upon it, without deflection or distortion, which could change the curve of the intrados, and perhaps ruin the arch. In all cases the dimensions of span width and rise should be given by the engineer, and in special cases the centre planned by him. If the abutments of the arch are high, the centre should be supported so that it may be gradually lowered to allow for the shrinkage of the abutments, also to allow the arch to settle together slowly while the mortar hardens.

The centre should never be struck until the arch is loaded uniformly with the masonry above; and in a series of arches

with light walls between, no centre should be struck until the last arch is built at the abutment wall or pier.

Large arches with light abutment walls and very little weight above, as arches in towers, are liable to spread and crack. This can be prevented by imbedding iron rods with a plate at each end just above the arch.

Corners, angles, and junctures with cross-walls, can be strengthened greatly by the use of iron plates, rods, or other ties. The use of iron in connection with brickwork should, however, be limited, on account of the difference of expansion of iron and brickwork due to heat.

The requirements for good brick are as follows: to be regular in shape, with plane, parallel faces, and full, sharp edges at right angles to each other; to give a ringing sound when struck together, and, when broken, to show a hard, uniform structure free from air bubbles and cracks; to absorb not more than $\frac{1}{15}$ their weight of water.

Common brick of good shape and color, laid with close joints, are the most appropriate for mill-work, although some pressed brick are used. Round-cornered brick, with one corner rounded, can be used to advantage both for appearance and durability, for window and door jambs inside the building. They can be obtained of the same quality and at the same price as the regular shape.

The thickness of the joints is usually determined in the specifications, by stating how much five courses laid shall measure; for instance, five courses to the foot, or five courses to $11\frac{3}{4}$ inches. In order to be able to specify this, the size of the brick must be known. Measure five courses piled up dry, and add $\frac{1}{4}$ inch or less for each joint. About $\frac{3}{16}$ of an inch for a joint is a good allowance for ordinary work.

A few courses having been laid up, the joints are run over by a tool called the jointer. The shape of this tool should be rather more blunt than sharp, so that the joints are not dug in too deep, as is the general tendency. A straight edge must always be used in jointing. For inside work to be painted or whitewashed, the joints are sometimes "struck." This is done

with the point of the trowel, making a flush joint. But the most satisfactory and substantial way is to joint with a round-nosed jointer, and not very deep. This can be easily painted or whitewashed, and looks well. For exposed inside work it is customary to specify that it shall be laid equally well as the outside; there is no need, of course, for culling the brick for color on the inside.

If an inspector of brickwork, usually a practical brick-mason, is not employed, the engineer cannot be too sharp in watching this portion of the work, and should immediately correct any thing which tends towards bad workmanship, and on any second offence should insist on the discharge of the offender. To begin properly and a little severely at first, may make a great difference in the character of the work. I have seen men working by the day, and not on contract work, who would lay in bricks dry for no apparent reason except not to be beaten by their neighbors.

On the quality of the lime used depends greatly the strength of the walls. Lime will very rapidly deteriorate if stored in a damp place; it absorbs moisture from the air, and will never harden if used. If exposed to the air even for several months, though not in a very damp place, it will deteriorate more or less. It can be kept good for a long time in a ground state if stored in air-tight casks in a dry place. Lime may be tested roughly by slaking it, and observing the results. If well-known brands have not been injured by water or air, they are all right for use. If a cask is opened, and its contents is partially reduced to powder, there is an indication that it has been injured. If the remainder in lump on being put into water does not slake, the cask must be rejected. If the lumps slake on the surface and leave a hard centre, the lime is unburnt and should be thrown out. The danger of using such lime is that the particles which remain unslaked at first absorb moisture after being used, and then slake or expand and throw out the joint. The effect of this may be seen in some houses where the plastering is blistered. Over-burnt lime remains inactive under water for a long time, and then slakes slowly. This must be rejected. Ground lime slakes quietly, and is usually hydraulic, setting in damp places.

In mixing lime mortar the lime paste is first prepared. The whole amount of water necessary should be added at the outset, which is about 1½ barrels to 1 of lime. An experienced mortar mixer will always do this. The lime expands while slaking, and occupies about 2½ times the space of dry lime. This paste should be allowed to stand as long as possible after all the lumps are dissolved before adding the sand. Cement mortar must be mixed and used immediately, while lime mortar is better for age. A mixture of lime and cement produces a stronger and quicker setting mortar, and for damp places it is necessary to add cement to ordinary lump lime.

A man supplied with brick and mortar on straight outside work, with the bond, headers every fifth course, should lay 1,500 bricks a day, and in filling in or "backing up," as it is called, on inside work, 2,500 a day. On massive work, such as foundations, engine-beds, etc., 4,000 to 5,000 can be laid, — length of day ten hours.

The weight of ordinary brickwork is about 125 pounds per cubic foot where one-fifth the whole contents is mortar.

One barrel of lime will lay about 1,000 bricks; one barrel of American cement, about 500 bricks.

The number of bricks per cubic foot will vary with their size. Bricks, measuring about 7¾ inches long, 3½ inches wide, and 2⅜ deep, will take about 24 for a cubic foot. In estimating the amount of brick required, it is well to add from 2 to 3 per cent on massive work, and 5 per cent for light walls, where a good many are wasted in cutting. Before ordering, it is necessary to know the size of the make to be ordered.

The pressure per square foot of brickwork in lime mortar should be limited to 8 tons for mill-work, and this should not be exceeded except in extreme cases, and then more cement should be used.

STONEWORK. — Before making any plans for the stonework, the size of brick and allowance for thickness of joints must be known. For instance, it has been decided to use brick which measure 11 inches for 5 courses when piled up dry, that the allowance for joints shall be $\frac{3}{16}$ inch, making a height of very

nearly 12 inches for 5 courses laid. On this basis we may go ahead with the plans for stone, or other trimmings.

Of all building-stone the best qualities of granite are the strongest and most lasting, and its presence in large quantities in New England has caused it to be used almost exclusively for mill purposes. The toughest and hardest granites are usually the strongest and most durable. Durability is indicated by the predominance of quartz and hornblende, and smallness and lustre of crystals of felspar.

Hardness increases the cost of cutting, and for this reason judgment can be used as to the degree of hardness required. For ordinary building-purposes the hardest granites are not required; but, in places where it will be exposed to severe strains or jars, the toughest is the best. For heavy engine foundations the strongest stones should be used. On account of the difficulty of cutting, and decrease in freight for lighter weights, the stones are sometimes cut at the quarry, where men are employed who are accustomed to working that peculiar kind of stone, and who can take every advantage of their experience. Extremely large blocks are almost always cut at the quarry, where the facilities for handling and working are greater than elsewhere.

The fineness of cutting for mill-work should not be carried to extremes. Good pene-hammered work is all that is required for washes, steps, etc. Quarry-face surfaces are appropriate, giving the idea of solidity rather than fine finish. All joints for beds should be reasonably full, but not smooth, as slight depressions tend to hold the mortar in place. Occasionally a key or date stone or something of that sort will require six-cut work, but nothing finer than this is ever required. Large coping-stones and flagging can be rough pointed on top.

Granite can be used with safety for underpinning, date-stones, door-sills, steps, and window-sills, but should not be used for window-caps: brick arches should here be used. Where granite is exposed to heat and water, exfoliation takes place; but, if its use is restricted to that given above, there will be no danger.

When stone and brick are laid together for a considerable

height, as when stone quoins are used for the corners and brick for the rest of the building, there is great danger of cracking the brickwork and bringing undue pressure upon the stonework; for in the stonework the joints are fewer than in the brickwork, usually one to five or more, and the unequal shrinkage produces bad results. For this reason it is well to avoid such construction to any considerable extent.

When the pressure is great at the extreme edges of two adjoining stones, they will usually scale off, leaving ugly scars. This may be prevented from happening by pressure, although it happens very often through careless handling, by keeping the stones full at the joints everywhere except for a space of an inch or two from the edge. In this way the pressure will no longer come on the edge of the stone.

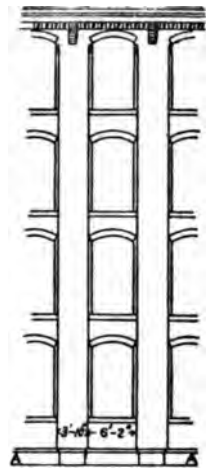


Fig. 7.

The general outline for a four-story pilaster mill is shown in Fig. 7. The proportion of pilaster to panel is adapted for bond of Hooksett brick. The underpinning is shown at *A A*, and has usually a 3 or 4 inch wash.

SECTION IV.

Floors and Roofs.

Basement floors, unless used as other floors, are usually paved with brick, or concreted. If the soil is dry, a very firm and durable floor can be made of brick, by first putting in about a foot of sand or gravel, if the soil has a tendency to heave; on this, laying a course of brick flatwise, and then another course edgewise, or "bull-headers," as the masons call it. These are laid in cement mortar, and then grouted full. When this is set

up, it will form a solid mass which will stand a great deal of hard usage.

In wet or damp soils the pressure of water, if allowed to collect, might be so great as to break up through the paving unless there were a relief. In such places, blind drains are run round the building, formed by digging trenches and filling them with loose stones. These drains are all connected together, and discharge at some convenient point to the outside. A common and very good way to make a floor in such places is to spread about a foot of broken stones over the whole surface, the larger ones at the bottom, and above this to spread about four inches of cement or asphalt concrete. In this case also it is well to have a few drains lower than the general bottom of the stone, to lead away the water. Cement concrete is usually preferred to asphalt, and is prepared and put down as follows: The proportions of good clean gravel to cement are four to one. This is mixed up thin enough, so that, when laid down and floated, the cement will come to the top and make a smooth floor. It is put down in sections; but, as one section is never dry before the next is laid, they will join together. The thickness should be three to four inches. The proper way to get the surface is to make it from the first layer, and never to make a rough layer and then put on a skim coat; for with rough usage this skim coat peels off, and is the beginning of a rapid destruction of the whole floor.

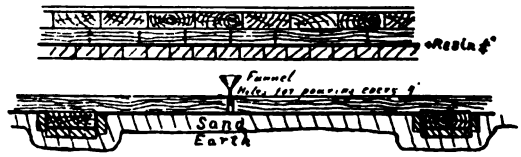


Fig. 8.

When machinery is to be placed in the basement, some other floor than those above described must be used. In "Special Report," chap. 18, of the Boston Manufacturers' Mutual Fire Insurance Company, will be found descriptions of two floors which have proved very durable, — one as used by William Sellers & Co., and shown in Fig. 8, which explains itself.

Another, as shown in Fig. 9, is used at the Yale & Towne Manufacturing Company, for a shop floor.

The concrete is made up of about six inches of coarse stone; five inches of concrete, made of coarse gravel, coal-tar, and pitch; and, finally, one inch of fine gravel concrete. The timbers on the under side of the flooring were covered with hot tar. Refined coal-tar must be used.

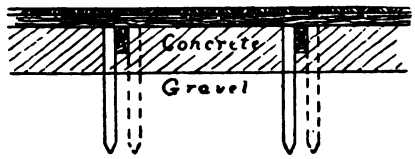


Fig. 9.

Basement floors, where there is a sub-basement or cellar, are usually made like the floors above them. There are very few of the so-called fireproof mills in this country. The floors in these buildings are usually formed by springing flat, brick arches between I-beams, which are supported by the columns. A lighter floor is now built of hollow-tile arches sprung in the same way. The methods are expensive, and extremely inconvenient for hanging shafting, fastening machinery to the floor, cutting belt-holes, etc. The floors are too rigid, giving no cushion for the machinery, and thus increasing the expense of maintenance of the same. This sort of floor is excellent for washrooms, dye-houses, etc., where water is continually being spilt; for a wooden floor would soon give out.

The best form of floor for ordinary practice consists of Southern pine timbers running across the mill at uniform distances apart, about ten feet, covered with spruce plank, with a top floor of birch or maple. Between the plank and top floor some waterproof material is laid, usually two thicknesses of tarred paper. The under side of the plank may be sheathed with pine sheathing. (See Fig. 10.)

Southern pine can be obtained in abundance in convenient dimensions, and is strong, flexible, straight grained, and usually free from knots, and forms the best mill-timbers. The usual

size for floors is 7×16 inches, double; that is, two 7×16 inch timbers bolted together. There are two important advantages of double timbers over single ones. If whole timbers were ordered 14×16 inches, they may be sent with unsound heart; but if they are sawed open, the hearts, if very bad, drop out; and if the timbers are poor, they will not be sent to be rejected, thus insuring better timber to begin with. Afterwards, in framing the timbers, it is probable that the average strength is more nearly approached by bolting a stronger and weaker half-timber together, while with the whole timbers the weakest stands for itself. Thus we have a less variation from the average strength. The half-timbers also season more rapidly than the whole ones.

These timbers are planed on three sides for all floors that show. In the sub-basement they may be left rough.

The double timbers are fastened together by ¾-inch bolts, the heads and nuts of which press against cast-iron washers 4 inches in diameter and ½ inch thick. If smaller washers are used, when the timbers shrink and twist, the washers will cut into the wood. A one-inch air-space is left between the timbers. They are framed to fit around the columns or pintles, and, when in place, they are brought together end to end, and the end joints sawed together. The ends of abutting timbers are fastened together by dogs of ¾-inch iron, which are about 22 inches long after bending. Each end is turned up nearly, but not quite, at right angles to the bar. The ends are driven into holes in the tops of the timbers, and the fact of their being bent not quite to 90 degrees, tends to draw the timbers together when the dogs are driven. The planking covers the dogs. They are also fastened together on the under side by lag-screws through the caps of columns or pintles. Fig. 10 shows the above methods. *D* are the dogs, *B* the ¾-inch bolts, and *L* the lag-screws.

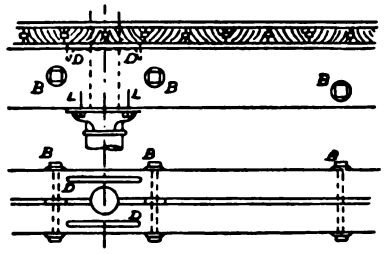


Fig. 10.

The two most common ways of fastening the timbers to the walls are as follows: One, of which the insurance companies do not approve, but which is very common, is to put a one-inch bolt through the timber, eight inches in from the wall. This bolt passes through the eye of another one-inch bolt, which lies between the timbers, the nut end being on the outside of the building, the nut pressing against a cast-iron washer. The timbers rest on a plate of iron or hard pine. The objection offered to this method of construction is, that, in case the timbers become burnt through, the wall will probably be pulled in. This method is shown in Fig. 11, where *A* is the one-inch bolt, *B* the eye-bolt, and *C* the outside washer.

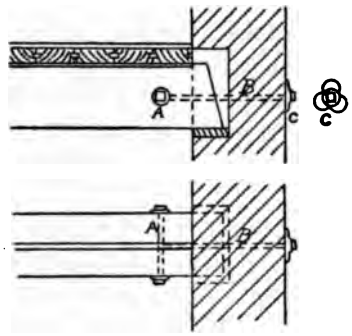


Fig. 11.

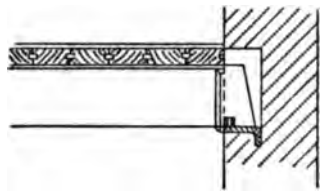


Fig. 12.

The other method, of which the insurance companies approve, is to have a cast-iron plate with a rib projecting above and below. The one below is to bind the plate to the wall, and the one above fits into a groove in the under side of the timber. The groove is cut large enough to receive the iron lip and a wooden wedge, which is driven in and draws every thing tight. The timber can tip and pull away from this without pulling the wall in. (See Fig. 12.)

All timbers are bevelled off at the end which rests on the wall, so that in falling down they will not act as a lever to overturn the wall. Of the above two methods, the first, in case of burning off and breaking the timbers, tends to pull the wall

in. The second will, under the same circumstances, tend to press the walls out, and as it will not stand without the support of the floors, it should properly go into the fire rather than outside, probably causing loss of life. Walls, if left standing, should not be used again, but should be rebuilt.

Spruce planks are strong, light, and can be obtained in abundance. The usual thickness is from three to four inches. In the best construction for 10-foot bays, 4-inch plank is used. They should be thoroughly seasoned before being laid. They should be planed on one side, and grooved $\frac{3}{4}$ inch square for splines, and should be of widths not exceeding 10 inches, and of sufficient length to span two bays, i.e., 20 feet long for 10-foot bays. With lengths sufficient to span two bays, they can be laid to break joints on the timbers, thus increasing the stiffness of the mill. They are also theoretically stronger when covering two bays, being in about the condition of a beam fixed at one end and supported at the other, while in spanning one bay it would approach more nearly a beam supported at both ends.

In spiking the planks to double timbers, it is well to drive all the spikes into one timber, two inches from the inside and outside, thus leaving one timber entirely clear for hangers, and the centre of the spiked timber also clear. This also does away with the effect of shrinkage of timbers and loosening of timber bolts, which would come into play if the end of one plank were spiked to one timber, while the adjacent end were spiked to the other half-timber. Another, and a great advantage in lapping the plank into one timber, is to have the end joints over the timber instead of over the opening between the timbers, which would allow dirt to sift through and water to run down through.

Seven-inch spikes are used for four-inch plank, of which one cask of 100 pounds will lay about 1,200 square feet of flooring. Steel-wire spikes and nails are now being used: the cost is more per pound, but the number per pound also greater, and the waste in usage less, so that the actual cost would be about the same as ordinary spikes. It is almost impossible to

pull the steel-wire nails out after they have been driven a short time.

Tarred paper should he laid down in two thicknesses, each over-lapping the preceding one one-half its width. This will keep the floor water-tight. Any drops of water coming from above might damage the work. The brand of the paper should be A No. 1; the roll is 150 feet long by 2 feet 8 inches wide, with an area of 400 square feet, one roll being required for every 200 square feet of floor-surface.

Sometimes a layer of mortar is spread between the planking and top floor, which makes the floor slow burning and absorbs the moisture. A very serious objection to this is, that small particles of mortar sometimes work through the floor, and drop into the machines below, cutting the rolls, etc., and in time of repairing the floor this becomes a nuisance.

Top floors are of birch or maple, or, if to receive constant drippings of water, Southern pine, jointed to uniform widths not exceeding four inches, and seven-eighths inch thick. One and one-eighth inch top floors are frequently laid; but the first cost is more than for seven-eighths inch, and the life not much longer, for the wear is about the same, and when the seven-eighths inch is worn so badly as to necessitate relaying, the one and one-eighth inch ought also to be relaid. The boards should be thoroughly seasoned before laying, or cracks will open, which, besides preventing a tight floor, will cause a more rapid wearing, as the corners of each board have then room to spread and crack off. Where practicable, the top floor should be laid with joints in the direction of the heaviest travel, as it is then much easier on the floor, trucks, and help. Seven-eighths inch top floors are nailed with ten-penny steel nails at the ends of the boards, and at regular intervals, extending across the building, of about fourteen inches. So many iron nails are bent and broken in driving through hard wood, that steel nails are cheaper. One cask of 100 pounds will lay about 2,000 square feet of floor surface. Steel-wire nails may be used here. After laying, the top floor is smoothed up.

In ordinary rooms the under side of the planking is covered

with pine sheathing three-fourths inch thick, of uniform widths, not exceeding four inches. The quality is that known as "good mill sheathing." In picker and dust rooms, and other rooms exceptionally liable to fire, the ceiling is covered with some fireproof material, such as plastering on wire lath, which is common practice. This should cover both planking and timbers. Another and newer substance is the magneso-calcite fireproof covering. This will stand an intense heat for a long time without deterioration, and is a poor conducter of heat.

PRESERVATION OF TIMBER. — Those floors are most lasting which are kept constantly dry and well ventilated. They are softened and weakened by being constantly wet, although not necessarily decayed, but when subjected alternately to wet and dry, they will decay. If exposed to dry but confined air, there is a liability to dry rot. The most efficient manner to preserve the timbers is to have them well seasoned, and exposed to a free circulation of dry air. Creosoting is sometimes used for timbers of basement stories which are exposed to dampness. The air and moisture are exhausted from the pores of the wood, and a pitch oil is then forced into the pores at about a hundred and fifty pounds pressure per square inch.

Protection against the absorption of moisture is oil paint; but this should not be applied for two or three years after the structure is built, or until the timbers are thoroughly dry. One hundred pounds of white lead on three-coat work, and varnished, will cover about 900 square feet of floor surface, or 1,100 square feet of painted surface. If mixed in oil, this would cover 2,800 square feet. This turns yellow.

An example showing the effects of using green lumber, and painting before seasoning, was in a mill built during the fall and winter of 1872. The lumber used was green white-pine timber; old-growth hemlock four-inch plank, cut and sawed, and put in as quickly as possible; Georgia pine one and one-fourth inch thick for top floor, and three-eighths inch pine sheathing underneath the planks; oak columns. The painting was done immediately after completing the building. No machinery was put in, and it was not heated for two years. In

1876 the mill was rebuilt. All the planking was so badly decayed that it was shovelled out. The timbers were gone for a depth of from three to four inches. Columns in the first story were rotted, and were replaced by new ones. The sheathing had all flaked off, and all that held the floor together was the one and one-fourth inch Georgia-pine top floor.

LOADS ON FLOORS. — The weight of the floor itself for ten-foot bays, double Southern-pine timbers 7×16 inches, four-inch spruce plank, seven-eighths inch maple or birch top floor, and three-fourths inch pine sheathing, is very nearly 20 pounds per square foot for the average. This is to be added to the net loads, in all cases, to obtain the gross load.

It is by far easier to estimate the load which a floor can safely sustain, than to *guess* the weight which at some future time may be put upon it; and unless some restrictions are placed on the method of storing or packing up goods and material, the estimated load may be greatly exceeded. Oftentimes a mill designed for light loads, as cotton manufacturing, will be rearranged for some other purpose, as finishing and packing, where heavy loads are to be supported, so that the load may approach too near the breaking strength for a feeling of comfort, should it be known. All that an engineer can do is to estimate the extreme loads to which the building under consideration is to be subjected when designed for a certain purpose, to allow a reasonable factor of safety, say six, and build accordingly, leaving his plans stating clearly the estimated loads per square foot allowable. A change, such as stated above, of use for a building, should never be made without a careful examination of the building and proper calculations beforehand.

In storehouses of two or more stories, the height of stories should be so limited that the floors cannot be overloaded to such an extent as to make them unsafe.

In ordinary cotton-mills the loads are light, and may be taken at 30 pounds per square foot of floor for machinery, material, and operatives, or 50 pounds, including the floor, constructed as described above. For worsted mills with heavy English looms, a gross weight of 60 pounds per square foot should be allowed

for. In finishing, packing, and storage rooms the weights are very much heavier. Cases of manufactured goods piled two and sometimes three high, and unpacked goods piled sometimes to the ceiling, and truckloads of press-paper grouped together, bring weights of from 100 to 200 pounds per square foot, and for such rooms there should be an allowance for 200 pounds per square foot, unless the height of the story limits the piling, and therefore the load. Storehouses for cotton, with low stories from 8 to 10 feet, designed to store the bales on end, have a gross load of about 100 pounds per square foot; if the cotton is compressed, 150 pounds per square foot. Storehouses for wool, of about 10-foot stories, are designed for the large sheets to stand on end, but which are frequently piled up solid to the floor above. English, Irish, and domestic wool stored on end give a gross load of about 80 pounds per square foot; call this 100 pounds, to allow for piling up. Australian wool is usually stored two bales high, and gives a gross load then of 150 pounds per square foot. If much of these wools, giving heavy loads, is to be used, it would be well to allow 150 to 200 pounds per square foot for all storage floors. If a small quantity is used, one floor might be made for loads of 200 pounds, and the remainder for 100 pounds, per square foot. If there is a possibility of storing cases of manufactured goods, then 200 pounds per square foot should be used. Usually the timbers and plank are the same size for all floors, and the calculations for additional weight would affect the size of columns only, and distance apart of the same; but occasionally, where one floor is to be stronger than all the rest for some special reason, triple timbers may be used, or the timbers trussed.

Under ordinary circumstances it will be safe to use the loads as given in the table. For net loads deduct 20 pounds per square foot.

TABLE SHOWING GROSS LOAD PER SQUARE FOOT.

Use of Building.	Load, in lbs., per sq. ft.
Cotton and Woollen Manufacturing	50
Worsted Manufacturing.	60
Storage of Compressed Cotton and Bales of Manufactured Cotton	150
Storage of English, Irish, and Domestic Wools . .	100
Storage of Australian Wool	150
Storage of Cases of Woollens — 2 high	150
Storage of Cases of Worsteds — 2 high	200
Storage of Machinery	200
Iron Repair-Shop	200

STRENGTH OF FLOORS. — In buildings devoted to manufacturing purposes, it is not the breaking strength of floors which concerns us alone, but also the allowable amount of deflection, which always occurs, to a certain extent, in unloaded floors. We might keep within the elastic limit, and yet have a deflection so great as to be very serious with regard to shafting and machinery on the floor. For this reason let us keep within a calculated deflection of one-half inch for all timbers, as figured from the formula $v = \frac{5}{32}\frac{Wl^3}{Ebh^3}$ (see Professor Lanza's Applied Mechanics, p. 301), where v = deflection = in this case one-half inch, W = load uniformly distributed, l = distance between supports in inches, E = modulus of elasticity, which for Southern pine should be taken as 1,200,000, b = breadth, and h = depth of timber in inches.

Should the deflection figure out an appreciable amount over one-half inch, the size or number of timbers must be increased, or the space diminished, by increasing the number of rows of columns. The latter is usually done, except in special cases where one floor is to sustain heavier loads than the rest, as mentioned before.

Keeping within this limit of deflection will usually give an

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ample factor of safety above the breaking strength. To calculate the bending moment, take the formula for a beam supported at both ends, and uniformly loaded, $M_b = \frac{Wl}{8}$, where M_b = bending moment, W = load, l = distance between supports in inches.

Moment of resistance, $M_r = nfbh^2$, where $n = \frac{1}{6}$ for rectangular beams, f = modulus of rupture, which should be taken at about 6,000 pounds for Southern pine, b = breadth, and h depth of timbers in inches.

M_r divided by M_b will give the factor of safety.

To calculate the strength and deflection of floor-planks, use the same formulæ, the only change being in the constants. The modulus of elasticity, E, for spruce = 900,000; and the modulus of rupture, f, for spruce = 4,000 pounds.

Roofs. — The roof of a mill, if poorly constructed, will give more trouble than any other part, by leakage during storms, or backing up of water from melting snow and ice, and by the condensation of moisture on the ceiling, and dripping of water, damaging the work and machinery.

The older custom of using small rafters about 12 inches apart, with boarding above, should be always avoided, as this is the poorest sort of a mill roof. The pitch roof is very wasteful of room, is expensive, and should not be used. The best form, and that which is now in general use, is known as the "flat roof." It has a pitch of ½ inch per foot. The materials are Southern-pine timbers 10 × 14 inches, placed one in each bay, covered with 3-inch planking of pine, and then covered with tin, gravel, or duck roofing. The timbers should be planed on four sides. The planks should be planed one side, and may be heavy beaded, giving the under side the appearance of sheathing, grooved ¾ inch square for splines, and of uniform width, about 6 inches. They should be well seasoned, or they will draw apart. The planks are spiked to the timbers with 60-penny nails, of which one cask will lay about 800 square feet of planking. The planks should be the length of 2 bays, and should be laid to break joints, as in the floors.

As to the covering, there is not much choice between tin and gravel, if each is properly put on. The expense is about the same for each. Duck is about as expensive, and less durable.

If tin is to be used as the covering, the planks are first covered with 3 thicknesses of tarred paper, laid so that each one overlaps the two preceding ones $\frac{1}{3}$ and $\frac{2}{3}$ its width. This is tacked down with $1\frac{1}{2}$ inch nails about every 2 feet apart through tin washers, $1\frac{1}{4}$ inches in diameter, and are so driven that the next layer of paper will cover them.

The tin is partially prepared before being brought to the roof, by making up the end joints, and so preparing a long roll, which, when unrolled on the roof, leaves only the side joints to

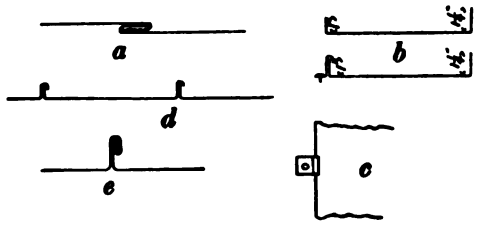

Fig. 13.

be made up. The end joints are put together as shown in Fig. 13 *a*, and are white or red leaded. Two rolls having been laid out flat, the method of procedure for making up the side joints is as follows: 1st, Turn up flanges 1 inch high on one edge, $1\frac{1}{4}$ inch high on the other, as shown in Fig. 13 *b*. 2d, Fasten down the 1-inch side with cleats, Fig. 13 *c*. 3d, Turn $1\frac{1}{4}$-inch flange down over one inch, Fig. 13 *d*. 4th, Last operation turn both flanges over together, leaving a rib $\frac{1}{2}$ inch high, Fig. 13 *e*. This form of joint, called the raised joint, will allow for expansion and contraction without injury to the tin.

The tin after it is laid is thoroughly painted. All flashing around vertical surfaces, as chimneys, fire-walls, etc., should be very carefully done, and carried high enough to prevent any rain or melted snow from climbing up over and running down on the back side.

The tin should be of the brand "M. F. Roofing Tin," 110 sheets to the box. One sheet when laid covers 1½ square feet. The cost of laying, when tin is $7.25 per box, is about 6 cents per square foot, exclusive of any profit.

If covered with gravel, the "Six-Ply New England Roofing" is a standard, and is laid as follows: Three thicknesses of tarred paper are laid down, as for tin roofing. This is covered with a thin layer of hot coal-tar; above this are laid down two more thicknesses of tarred paper for five ply, or three more for six ply. In putting these down, the edge of each layer which is exposed is stuck down to the one below with tar. On this is put another layer of hot tar, and then the gravel above this. This should be guaranteed for five years. The cost is about 6½ cents per foot, including profit. Heavy duck has been used somewhat, but will probably never come into general use.

THE WEIGHT OF ROOF, when covered with tin, for 10-foot bays, 10×14 inch Southern-pine timbers, and 3-inch pine plank, is about 11 pounds per square foot; with gravel covering, the weight would be about 13 pounds per square foot. These weights are very light, but after a heavy snow-storm, and the roof is covered, if rain sets in, saturating the mass of snow, the weight is very much increased. Twenty pounds is generally allowed in this climate as the load per square foot due to snow and wind, thus making for gross loads 31 and 32 pounds. The usual allowance in mill-work is 50 pounds, which will cover all emergencies.

THE STRENGTH may be calculated by the same formulæ as were given for floors. In practice a 10 × 14 inch timber for spans up to 23 or even 25 feet are considered ample, unless subjected to some other stress than that of the roof itself; and above a span of 25 feet the timber is trussed with iron rods. Three-inch planks are strong enough to cover every possible condition of ordinary use.

SECTION V.

COLUMNS.

THE discussion of the proper material and shape of mill-columns has been of late somewhat extended, but as yet no definite decision has been given that one material is absolutely superior to all others for every case.

In many of the finest and best built mills, and in many other large structures, iron columns are used exclusively for supporting the weights of floors. In favor of their use it may be said that under ordinary circumstances they are nearly indestructible. In damp places, iron should be used either alone or in combination with other material. If kept painted, it will last here for ages. In some cases of great loads to be supported, it becomes impracticable to use any thing but iron, the size required for wood being too large for practical use; and in all cases, there is less room taken up by iron, thus leaving more clear floor-space. With iron columns the number of bearing-surfaces can be reduced to about one-half that required for wood; and the less the number of joints, the stiffer the building.

Against the use of iron columns is the greater expense than of wood, the liability of snapping off by some sudden lateral blow, and the quickness with which they collapse in case of fire when cooled by a stream of water.

In favor of wooden columns are cheapness and slow-burning property, which may save the mill from falling in in case of fire. They give warning of weakness, usually, before rupture; in case of compression, the crippling of the fibres is shown, and too much lateral load is shown by bending.

The one great objection to wooden columns is, that in damp places they will decay, and as those places are generally visited or inspected less frequently than others, there is a danger of crushing them. Not long since some old columns were removed from a certain mill, and the bottoms of some of them which were exposed to dampness were so rotted away that it was

simply a wonder that they had not given away under their load of about twenty tons.

For mill buildings used for manufacturing purposes, iron columns are extensively used, and give good satisfaction. For mill buildings used for storage purposes, above the damp basements, if the loads do not require too large columns, they are usually of wood. Where extreme economy in first cost of construction is aimed at, wooden columns should be used.

There are many kinds of composite posts, made up of iron with wood, cement, tiles, or some other non-combustible or slow-conducting materials; but they are usually so expensive as to bar them from general use.

CAST-IRON COLUMNS. — If cast-iron columns are used, they should have no ornamentation which would make it difficult to get good castings or tend to diminish the strength. Ornamental columns belled out at the top or bottom are liable to be thin at the bell, where a severe shearing-stress is brought to bear. Although, perhaps, if larger in diameter at the centre than at the ends, the strength is greater for the same weight of metal, the increase of strength is slight. With the length very short in proportion to the diameter, the columns would give way by direct crushing, so that the strength is limited to that of the smallest section, while any increase in diameter of any portion above this would represent a loss. For these reasons, and because of the less trouble of making patterns and castings, and of the more pleasing appearance, the straight column of uniform diameter has been adopted almost universally. In all cases, each column should rest upon the one below, without using a pintle, thus making the number of joints a minimum.

There seems to be no appreciable difference in strength whether they are cast on end or horizontally, and as the latter method is very much less expensive, it can be used, care being taken that the cores are so supported that they cannot float and make a casting uneven in thickness. As the poorest metals are the strongest, they are used for this purpose; but any casting containing blow-holes or other imperfections should be rejected.

All bearing-surfaces should be turned up at right angles to the axis of the column.

All columns should be tested carefully before setting, and any which are radically imperfect should be thrown out, or broken up, to be returned to the foundry. The method of testing is as follows: 1st, Examine the columns for imperfections of casting. 2d, Draw a line from end to end, or put on a straight edge, to test the deflection. 3d, Measure the thickness at every two feet in length on each quarter of the circle. This last is done with long callipers, shown in Fig. 14.

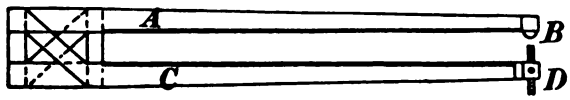

Fig. 14.

One arm *A*, on the end of which is an iron point *B*, is run into the columns. The other arm *C* is parallel to *A*, and about eight inches from it. At the end of *C* is a sliding scale *D*. When the scale is in contact with the point *B*, the reading is 0; when the thickness of metal is between, the scale will indicate its thickness. There may be a constant error caused by the deflection of the arm *C*, which is to be corrected for. A record of the measurements of each column is kept somewhat like the following table: —

No. of Column . . . . . 15 (simply a reference number.)
Weight of Column . . . . . 1,606 lbs.
Length, — Supposed, 16′-0″; Real, 16′-0 1/16″.
Diameter, — " 8 1/2″; " 8 3/8″.
Deflection, — " 0″.
Thickness, — " 1 3/8″.
Thickness by measurement for each quarter, every 2 feet.

1	2	3	4
1 3/8″	1 3/8″	1 1/4″	1 1/8″
1 3/8	1 3/8	1 1/4	1 1/8
1 3/8	1 3/8	1 1/4	1 1/8
1 3/8	1 1/4	1 1/4	1 3/8
1 3/8	1 1/4	1 1/4	1 3/8
1 3/8	1 1/4	1 1/4	1 3/8
1 3/8	1 1/4	1 1/4	1 3/8

Measurements in columns 1 and 2 in the table were directly opposite, as also were 3 and 4.

The readings above are very regular, and indicate a nicely cast column.

In order to have some standard for acceptance or rejection, we can do nothing better than to use that of Mr. Francis,[1] that the deflection shall not exceed $\frac{1}{300}$ the length, and the variation of thickness not more than two to one. Columns which do not come within this limit may be strong enough to bear with safety the load put upon them, especially if straight but of uneven thickness, for in these the thinner portion is chilled more than the thicker part, thus equalizing to some extent the strength. Should these be accepted, however, less attention will be paid to the rest, and a poorer lot all through furnished.

Occasionally, in a lot will be found one or two where the cores have floated to such an extent as to make nearly all the metal on one side and a mere shell on the other. If no test were made, these would go in as all right, and might lead to disaster; and if none are found bad enough to reject, the exact knowledge that every thing is of proper strength is worth a good deal of trouble, and a reasonable amount of expense.

The loads to be supported by columns are calculated from the same data as given for floors. The same remarks about the uncertainty of the amount of load which may come upon the floor, and provisions for such, are equally applicable under the head of columns. Besides this, there are other uncertainties as to the application of the load, which will be spoken of later on. These loads are applied on the top of each column. One portion, that of the floor immediately above, is applied to the ends of the caps, which, therefore, must be strong enough to resist the tendency to cross-breaking under this load. Another portion, the weight of all the floor above the column, excepting the one immediately above, and of the roof, acting theoretically along the axis of the column, but practically almost anywhere within the column. The body must be made strong enough to resist the total load of all the floors and roof above against direct crushing, or crushing and bending combined.

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[1] On the Strength of Cast-Iron Pillars. — J. B. Francis.

Hodgkinson's experiments, which are about the only ones on record on cast-iron columns, and which were conducted with great care, showed that columns with rounded ends, when the ratio of diameter to length did not exceed 1 to 15, gave way by direct compression and by bending when this ratio was exceeded. Columns with flat ends, very carefully fitted up and rigidly held. gave way by direct compression when the ratio of diameter to length did not exceed 1 to 30, and by bending when this ratio was exceeded. These experiments also showed that columns whose lengths are 30 diameters and above, with flat ends, are about three times as strong as those with rounded ends. Below 30 diameters the ratio of strength decreases when the ratio of length to diameter decreases. Columns with flat ends loaded eccentrically were about as strong as those with rounded ends.

For the strength of cast-iron columns, we have the valuable tables compiled by Mr. James B. Francis, "On the Strength of Cast-Iron Pillars." These tables are based on Hodgkinson's experiments and formulæ, and are calculated for safe loads for pillars with rounded ends, i.e., to have the rough bunches chipped off. Mr. Francis estimates that columns fitted up in the lathe and carefully set, would have a safe load of one and one-half times that given in the table.

Although the columns may all be carefully turned up and set up, there is still some doubt that every column has a true and firm bearing all around its base; and if it should have at the time of construction, there are reasons why it may not always remain so. One reason, which I think has not been generally noticed, is the shrinkage of the floor endwise. In almost every mill of solid construction, and especially where green timber is used, shrinkage and drawing away of floors from the end walls is noticeable, and the amount is in proportion to the length of the mill. There is a one-story mill about 800 feet long, where the floor has shrunk away from the end walls over two inches, and the end row of columns are about two inches out of plumb. The amount of shrinkage is probably in inverse proportion to the amount of seasoning which the lumber has received. With

ordinary lumber, as found in the market in large quantities, the shrinkage will approximate $\frac{1}{4}$ inch at each end for every 100 feet in length of the building, or $\frac{1}{2}$ inch total for every 100 feet. Particles of iron might get into the bearing-surfaces while setting the columns, and the column itself may not be turned off perfectly true.

If the floors are unequally loaded, the load on the column is eccentric.

For these reasons, it is perhaps safer to use the tables as they are given, considering the columns as eccentrically loaded, and so about the same in strength as those with rounded ends. Of course, with as much care taken as possible, the work done is very much better, and averages higher than it would otherwise.

WOODEN COLUMNS. — The best material for wooden columns is Southern pine. It is usually straight grained and free from knots, and has strength combined with durability. Oak is not as strong as Southern pine, and is liable to be knotty or with the grain twisted.

All wooden posts should be carefully examined, and any that are bad in this respect should be thrown out.

Until within a short time, the calculations for the strength of wooden columns have been very unsatisfactory. By taking the different authorities on the subject, as many different results could be obtained. Nearly all the formulæ are based on Hodgkinson's experiments on very small samples of selected wood, or on some other experiments conducted in a small way. The constants obtained for crushing-strengths were all too high; yet the supposition that the columns would give way by deflection, and allowance for the same in the formulæ, together with the large factor of safety allowed for wood, caused the final results to be in nearly all cases quite safe.

To determine the proper constants, and arrive at some formula which should express the breaking or safe loads for full-sized columns of ordinary length, a series of experiments were conducted at the Watertown Arsenal for the Boston Manufacturers' Mutual Fire Insurance Company, under the direction of Professor Lanza. These experiments have been carried far

enough to show that all the constants heretofore given for the breaking-strength of ordinary timber are too high. They also proved pretty conclusively that columns of usual lengths and diameters with flat ends, when subjected to a pressure uniformly distributed over each end, with the resultant as nearly as possible along the axis, would give away by direct compression, and that the bending effect was not noticeable. When the pressure was applied eccentrically, the constants were still lower.

A column between two pintles cannot be as rigidly fixed at its ends, as it is in the testing-machine with its ends bearing squarely against the face-plates, so that here again the constants would be lower. By the unequal loading of the floors there is caused eccentric loading on the columns.

Although the experiments are very valuable, as far as they have been carried, they do not give the data for establishing rules for each particular case of construction; and, as Professor Lanza urges, they should be carried far enough to establish with certainty those things which are now simply suggested as might happen under certain circumstances.

We must make the best use of the results as given, and to do this, I should advise using them in the following manner: As the columns are usually very green as they come for use, the modulus of rupture for direct compression is taken at 4,000 pounds per square inch for Southern pine, and 3,200 pounds for oak. If the ratio of length to diameter fall within the limit of about 24 to 1, as all columns of ordinary sizes do, the failure is assumed to take place by direct crushing, and the factor of safety taken at six. Thus the breaking-load would be expressed by $P = fS$ where $f = 4{,}000$ for Southern pine, or 3,200 pounds per square inch for oak, and $S =$ sectional area in square inches, and for the working loads $f = \frac{4000}{6}$ and $\frac{3200}{6}$ or 667 and 533 pounds per square inch respectively, for Southern pine and oak. As it takes considerable time for the construction and equipment of a mill, the columns have a chance to season, and at the time when the full load is applied, the crushing-strength will have

increased, possibly to one-fourth of its original value, and likewise the factor of safety. It will be none too large; for as we have figured on direct compression, with the load applied along the axis of the column, we now probably have a load which is applied eccentrically.

Although the greatest care may be taken in setting the columns, there is the same liability of being thrown out of plumb, as has been shown before for iron columns, and the unequal deflection of floor-timbers causes unequal loading.

All wooden columns should be bored accurately through the centre, from end to end, with about a 1½ inch hole, to prevent undue checking of the wood as it shrinks. These holes should properly be bored from one end instead of each end toward the centre, for many times the holes would not meet in the centre, and thus the circulation of air would be prevented. If the hole is very eccentric to the column, the column is weakened, and the amount of eccentricity should be limited to an inch. One-half inch vent-holes are made either in the column or iron cap.

Preservation of Columns. — Iron columns may be painted at once; and a coat of oil paint, applied when necessary, will always keep them in good condition. Wooden columns should not be painted for at least two years after they are put in, in order that they may get thoroughly seasoned. Painting too soon will prevent the moisture from coming out, and so cause dry rot.

Pintles.— With iron columns the use of pintles is avoided, the bottom of one column resting upon the cap of the one below. With this arrangement there is a minimum number of bearings. (See Fig. 15.) With wooden columns there is need of a pintle or block to transmit the pressure from column to column through the floors. (See Fig. 16.)

The wooden column itself cannot go down through the floor, for the water used in scrubbing up would run down between it and the floor, and very soon cause decay. A very common method, used in nearly all the old mills, for transmitting the pressure, is to have an iron base, in which the bottom of one

column stands, resting upon a cast-iron pintle, which is made in various forms, — rectangular, circular, cross, etc.; and this pintle rests upon the cast-iron cap of the column below. In many cases these are rough, as they come from the foundry. This makes four bearings for each column. Sometimes the base and pintle are cast together, reducing the number of bearings to three. In new buildings the base pintle and cap can be cast in one piece, thus reducing the bearings to two in number for each column, which is the minimum for wooden columns. (See Fig. 16.)

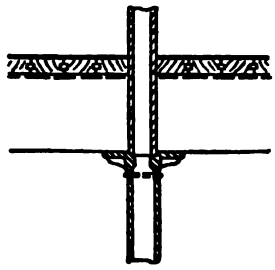

Fig. 15.

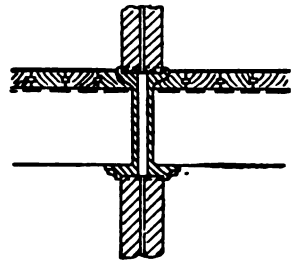

Fig. 16.

All bearing-surfaces should be faced up at right angles to the axis of the pintle.

With the above arrangement (Fig. 16), we have the least liability for eccentric loading, and a corresponding weakening of the columns, the least number of surfaces to finish, and withal a stiffer building.

As to the shape of the pintle, opinions differ; but for round columns the circular form would naturally distribute the load better, and is a very easy form to handle in finishing, by turning off the bearing-surfaces in the lathe. With the same amount of metal it is stronger in the circular than the cross form, and as strong as the rectangular shape.

All caps must be of iron. No wooden bolsters should be used as caps under any consideration, as they will crack and weaken the columns greatly. The length of a cap ordinarily would be 18 to 20 inches for floors, and 16 to 18 inches for the roof. This

length gives 9 to 10 inches bearings for floor-timbers, which is ample. If the caps are made longer, the strength and weight must also be increased. Holes are cast in the caps for lag-screws to pass through into the timbers, — 4 in the floor, and 2 in the roof, timbers. Fig. 17 shows a roof-cap.

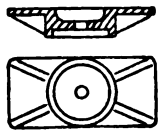

Fig. 17.

SECTION VI.

Other Details.

Doors. — All inside doors leading from one room to another through brick walls, or from rooms to stairways and towers, should be fireproof. When swing doors are used from rooms to stairway or other towers, which should always be closed, they should be hung with stiff spring hinges, and whether swing or sliding doors are used to close openings in fire-walls, which are liable to be left open, they should be provided with some automatic self-closing arrangement in case of fire.

The best form of fireproof door is made from a double thickness of seven-eighths inch sheathing, nailed together diagonally with wrought-iron nails clinched on the back side, and this covered with tin put on in such a manner as to be as nearly air-tight as possible. If shutters are to be used, they also should be made in this form. Iron should not be used, at it has proven wholly inefficient against a hot fire. These doors should fit as closely as possible against the brickwork, so as to shut off all communication beyond.

Outside doors may be made according to the fancy of the architect or engineer, provided they are strong. Doors used for shipping-purposes are sometimes covered with sheet iron, and the frames made of cast iron tied into the brickwork. All doors used for exit of operatives should open out, to prevent any possibility of a jam in case of fire or accident. In storage buildings it is well to arrange the doors opposite each other on the same

floor, and to provide them with a solid door for shutting at night, and a slatted one for the day, thus allowing a constant draught of fresh air to circulate through. These are usually sliding doors.

WINDOWS. — In buildings used for manufacturing purposes, the largest amount of light consistent with strength is desired. This can be obtained with the style of mill designated as the "pilaster" mill, in which the piers or pilasters supporting the timbers are eight inches or more thicker than the panels containing the windows. The requisite strength of walls is obtained by increasing the thickness through, while the length of the piers is diminished, and wider windows used. In a mill with ten-foot bays, good proportions for four or more stories are about three feet six inches to four feet on the pilasters, and six feet six inches to six feet in the panels, dependent somewhat upon the size of the bricks used, and the bond of the same. This will allow for wide windows, which may be divided in the centre by a mullion, thus making the sash one-half the width, and more manageable than if full width. Buildings of one or two stories may have still wider windows, if desired. Smaller windows should be used in storage buildings.

The larger the windows are, the colder will be the building, and the more steam required for heating it.

Mill windows should be made with sash and frame about double the strength of those for ordinary purposes, on account of the constant jar and rough usage to which they are subjected. The size of the glass should be rather small, and of uniform size as nearly as possible throughout the mill, to save the expense of resetting. For the same reason segment-top sash should be avoided. The frames may be segment top while the sash are square. The quality of glass is, first quality American or second quality German, although second quality American is largely used.

STAIRWAYS. — Stairways as a usual thing should be fireproof, separated from the mill proper by brick walls, with all openings closed by tinned doors. An economical method of building such stairways, is to build the outside walls up with the mill first,

and later to bring up a centre pier of brickwork, at the same time setting up the stairs, which are cast iron scored on top. This makes a thoroughly fireproof tower at a very reasonable cost. The best form is to divide the flights, so that there are two landings for each story, thus making short, straight flights, which lessens the danger of crowding. In some instances it will be necessary to adopt a spiral stairway, which can be done successfully by building the central pier large enough to make a good tread, even at the narrowest end.

The location of stairways depends upon the size of the mill. One central tower, however, is insufficient. There should at least be one at each end; and if the mill is particularly long, an additional centre tower.

BELT TOWERS. — In the newest and best mills, all the main driving-belts are separated from the mill proper by brick partitions, and are located either at the end of the mill, or for very large mills at the centre, or in towers outside of the mill, built for this purpose. In this way one of the greatest dangers from fire is avoided. Belts running up through the floors, for many stories sometimes, carry the fire along with them, rapidly spreading it through the mill. These towers are shut off from the mill by fireproof doors.

FUTURE GROWTH. — We have now touched all the essential points on the construction of a mill. A few words will not be out of place here regarding the future of any building. No person can say what will happen; but, reasoning from experiences of the past, we know that every thing will not remain as planned at first. The prospects of future growth or development of business, and a corresponding enlargement of the works, should not be overlooked, and we are able to anticipate this to a certain extent with a small increase in first cost.

For example, you are called upon to design a mill for twenty thousand spindles. The prospects are that if business is good and the mill successful, that the capacity will be doubled in ten years. How will you anticipate this increase? By arranging the buildings so that they may be extended with the same number of floors, or by planning the original buildings with founda-

tions, walls, columns, etc., strong enough to sustain the weight of additional stories; or by a combination of both methods, and by making provisions whereby the motive power and distribution of power may be increased at not too great an expense. The practice of putting up a building here and there, as present requirements necessitate more space, will finally end in a collection of buildings inconveniently arranged in themselves and with relation to each other, and will prevent successful competition on small margins of profits with other mills conveniently arranged, and finally necessitate a general remodelling or destruction of the whole concern. Examples of this sort are often seen. It may not be possible to foretell what will happen; but with some regard to the future growth, a great deal of useless expense and labor may be saved.

SECTION VII.

Calculations, Plans, Schedule of Materials, Specifications, and Contracts.

1st. As has been before stated, the matter of calculating the requisite dimensions for the various portions of a mill would not be difficult, could we tell just *how* the loads were to be applied, and to what extent they might reach. As we cannot actually tell this, we must assume from general principles the loads which may at some time be applied, and use these with a good deal of judgment. Judgment is the most essential quality of the successful engineer. It covers all contingencies and unknown quantities, and tells how far we can economize in materials used, or labor saved, without injuring the stability or lessening the strength of a structure. Sound judgment will also keep the spirit of economy under control, so that it shall not get the upper hand of one. It will point out the weakest place in a structure, which, of course, is its limit of strength; all parts which are made stronger being a waste of strength and

material. You should always keep the expense down to a minimum, at the same time being generous within certain economic limits. To the young engineer, I would privately give this advice. Make a thing just a little too strong, and nobody will probably ever know it. Make a thing a little too weak, and everybody will know it. And, if I am not greatly mistaken, this is the secret of success of some of our most celebrated engineers.

2d. CALCULATIONS. — Let us take for a practical example the design for a storage building, for wools of all kinds, with wool-sorting in the upper story. The example will give us heavier loads to deal with than if we took a cotton-mill. The first floor is to be used for general storage, if required.

The gross loads for square foot of floor should be taken as follows: —

1st Floor	General Storage,	200 lbs.	per sq	ft.
2d, 3d, and 4th Floors,	Wool Storage .	150	"	"
5th Floor	Wool Sorting .	100	"	"
Roof.	Gross load for Roof, Snow, and Wind,	50	"	"

The building is to be of the description known as pilastered, and the brick to be used form a good bond with dimensions of pilaster 3 feet 10 inches long, and panels 6 feet 2 inches long; the pilasters to be 8 inches thicker than the panels. These are the dimensions which we propose to use. The lot on which the building is located limits its size to 105 feet in width by 204 feet in length, outside measurements.

The usual thickness at the top of the underpinning for five stories, is 28 inches through the pilaster; 105 feet — 4 feet 8 inches = 100 feet 4 inches inside width. If we first try a distance between columns of 20 feet for 10-foot bays, we should find the deflection of timbers for 200 pounds per square foot, above the safe limit, and the size of wooden columns, which we propose to use in all stories except the basement, would be too large for convenient use. So we will figure through for five rows of columns with a distance apart of 16 feet 9 inches, and 16 feet 8 inches from first row to wall on first floor. The length

of cap on column is 18 inches, giving a span on timbers between ends of caps of 15 feet 3 inches, and between columns and wall, of 15 feet 11 inches, say 16 feet. The area supported on this double timber would be $16 \times 10 = 160$ square feet, or a load of $160 \times 200 = 32{,}000$ pounds $= 16{,}000$ pounds for a half-timber.

For the deflection we have

$$v = \tfrac{5}{32}\frac{Wl^3}{Ebh^3},$$

where W = the load, 16,000; l = length in inches = 192; $l^3 = 7{,}077{,}888$; E = modulus of elasticity = 1,200,000 for Southern pine; b = breadth of timber = 7 inches; h = depth of timber = 16; $h^3 = 4{,}096$.

$$v = \tfrac{5}{32}\frac{16{,}000 \times 7{,}077{,}888}{1{,}200{,}000 \times 7 \times 4{,}096} = 0.514 \text{ inches.}$$

For loads of 150 lbs. per sq. ft., $v = .514 \times \frac{3}{4} = .386$.

The bending moment, $M_b = \dfrac{Wl}{8}$, where W is the load in pounds, and l the length in inches.

$$M_b = \frac{16{,}000 \times 192}{8} = 384{,}000 \text{ inch-pounds.}$$

The moment of resistance, $M_r = nfbh^2$, where $n = \frac{1}{6}$ for rectangular beams, b = breadth, and h the depth in inches.

$$M_r = \frac{6{,}000 \times 7 \times 256}{6} = 1{,}792{,}000 \text{ inch-pounds.}$$

$$\frac{M_r}{M_b} = 4.66 = \text{factor of safety, with 200 lbs. per sq. ft.;}$$

or

$$6.21 = \text{factor of safety, with 150 lbs. per sq. ft.}$$

Between columns, these factors would be increased to

5.38 for 200 lbs. per sq. ft.,

and

7.19 for 150 lbs. per sq. ft.

Having thus established the distance between centres of columns 16 feet 9 inches, we can proceed to calculate the pressures on columns, and piers supporting columns, and the sizes for the same.

The floor and roof area supported by each column = 16.75 × 10 = 167.5 square feet.

TABLE SHOWING THE WEIGHTS SUPPORTED BY COLUMNS, AND SIZES OF THE SAME.

1	2	3	4	5	6	7	8
	Weight on each Floor.	Aggregate Weights.	Breaking Areas, in sq. ins.	Safe Area, in sq. ins.	Diam. for Safe Load.	Diam. to be used.	Remarks.
Roof,	8,375	8,375	2.094	12.564	4	7	* Instead of using wood 16 ins. in diam., use iron column 9 ins diam. × 1⅛ in. thick. (See Francis's tables.)
5th .	16,750	25,125	6.281	37.686	7	8	
4th .	25,125	50,250	12.562	75.372	10	10	
3d .	25,125	75,375	18 844	113.064	12	12	
2d .	25,125	100,500	25.125	150.750	14	14	
1st .	33,500	134,000	33.500	201.000	* 16	* 9″ × 1⅛″	

EXPLANATION OF TABLE.

Cols. 1, 2, and 3 are plain enough in their headings.

Col. 4. Crushing strength taken at 4,000 lbs. per sq. in. for Southern pine.

Col. 5. Factor of safety of 6 used with the above modulus of rupture. (See p. 42.)

Column 6. Diameters of circles whose areas are in Col. 5.

Col. 7. Diameters used.

SIZE OF PIERS SUPPORTING COLUMNS.

Aggregate Load at Basement	134,000 lbs.
Weight of Columns and Castings, about	2,500 "
68.25 tons =	136,500 lbs.

Maximum pressures per sq. ft. of brickwork, 10 tons; requisite area, 68.25 ÷ 10 = 6.825 sq. ft. Our brick will lay with good bond 2 ft. 7 ins. = 2.52 ft. square; $\overline{2.52}^2$ = 6.35 sq. ft.; or 2 ft. 10½ ins. = 2.87; $\overline{2.87}^2$ = 8.24 sq. ft.

68.25 ÷ 8.24 = 8.28 tons per sq. ft.; and this is the size to adopt.

Foundation under Piers. — The nature of the soil is such as to limit the pressure per square foot to $1\frac{1}{2}$ tons. The load to be sustained is 68.25 tons + 5 tons, allowance for weight of pier and foundation underneath = 73.25 tons total.

73.25 ÷ 1.5 = 48.8 square feet, or 6 feet × 8 feet = 48 square feet. In this case, with the trench 6 feet wide, the load should be distributed over the 10 feet in length, which constitutes the bay.

Pressure on Walls. — The maximum pressure on brickwork laid in lime mortar is to be 8 tons per square foot. The general rule, for pilaster mills, for the thickness of wall, is to make the thickness of pilaster for two upper stories 20 inches, and to increase the thickness 4 inches for every two stories on the way down. For extra heavy loads this will not hold good. Let us calculate the pressure supporting the whole load as supported by the pilaster only. This makes a slight error on the safe side for full width of windows, but with narrow windows the load is partly supported in the panel. These areas and pressures are shown in the next table.

Table showing Pressures on Pilasters, and Area of Same.

1	2	3	4	5	6	7	8	9	10	11
Location of Area for Calculated Pressure.	Cu. ft. of Brickwork in Pilaster.	Cu. ft. of Brickwork in Panel.	Cu. ft. of Brickwork in Pilaster and Panel.	Weight of Brickwork in Pilaster and Panel.	Weight of Floor, or Roof	Total Weight of Brickwork Floor, or Roof, in lbs.	Total Weight in tons.	Aggregate Weight in tons.	Area of Pilaster, sq. ft.	Pressure per sq. ft., tons.
At 5th Floor,	92.74	69.20	161.94	20,242	9,500	29,742	14.87	14.87	6.40	2.33
4th "	64.00	32.00	96.00	12,000	8,500	20,500	10.25	25.12	6.40	3.93
3d "	76.60	76.25	152.85	19,110	12,750	31,860	15.93	41.05	7.66	5.31
2d "	76.60	76.25	152.85	19,110	12,750	31,860	15.93	56.98	7.66	7.44
1st "	89 24	103.00	192.24	24,030	12,750	36,780	18.39	75.37	8.92	*8.45
Underp'g	50.00	–	50.00 / 805.88	6,250	17,000	23,250	11.63	87.00	10.23	*8.52

* Additional supporting area in panels will reduce these pressures to below 8 tons per sq. ft.

EXPLANATION OF TABLE.

Col. 1. Location of sections for calculated pressure are taken just at the top side of each floor.

Col. 5. Weight per cu. ft. of brickwork, 125 lbs.

Col. 6. Weights for floors and roof same as given before,—one-half the load between first row of columns and wall being supported in walls.

Col. 10. Areas are, for length of pilaster, 3 ft. 10 ins., and thicknesses as follows: At 5th and 4th floors, 20 ins.; at 3d and 2d floors, 24 ins.; at 1st floor, 28 ins.; at underpinning, 32 ins.

PRESSURE ON FOUNDATION.—Stone in foundation for 10 ft. in length, 490 × 150 cu. ft. = 73,500 lbs. = 36.75 tons.

Preceding weight at underpinning (see table), 87 tons.

Weight of brick in panel below first floor, not added in before, 5 tons.

36.75 + 87.0 + 5.0 = 128.75 tons, total weight.

Maximum pressure per sq. ft., 1.5 tons.

128 ÷ 1.5 = 85.3 sq. ft., or a width of 8.53 ft., say 9 ft.

ROOF TIMBERS.—Regular size, 10 × 14 ins.

$$M_b = \frac{Wl}{8} = \frac{8{,}375 \times 183}{8} = 191{,}578.$$

$$M_r = nfbh^2 = \frac{6{,}000 \times 10 \times 196}{6} = 1{,}960{,}000.$$

$$\frac{M_r}{M_b} = \frac{1{,}960{,}000}{191{,}578} = 10.2 \text{ (between columns)}$$

9.8 (between columns and wall).

FLOOR PLANK.—4-inch spruce.

Span = 10 ft. — 1 ft. 2 ins. = 8 ft. 10 ins. = 106 ins.

$$M_b = \frac{106 \times 1{,}766}{8} = 23{,}399.5.$$

Load = 8.83 × 200 = 1,766 lbs.

$$M_r = \frac{4{,}000 \times 12 \times 16}{6} = 128{,}000.$$

$$\frac{M_r}{M_b} = \frac{128{,}000}{23{,}399.5} = 5.47 \text{ for 200 lbs. per sq. ft.}$$

3d. PLANS. — The plans necessary for the construction simply of a mill, are usually as follows: —

Foundation Plan, including details of any special work on the foundations.
First Floor Plan.
Cross Sections, one or more.
Elevations, two or more.
Details of Stone-work.
Details of Cast-Iron Work.
Details of Wrought-Iron Work.
Details of Windows and Doors.
Details of Stairways.
And details of any special departure from general work.

As these plans are usually the only thing left on record, calculations and notes being private property of the engineer, they should clearly set forth the safe limits of loads to be applied, and should show plainly the construction of each part. A generous description by the use of notes where needed in the detail plans will aid the mechanic wonderfully, and oftentimes prevent mistakes. There should not be the slighest chance for reading a plan wrong so far as concerns the plan itself. If any changes are made during the process of construction, they should be recorded in the "note-book," and indicated in the plans at the earliest convenience.

4th. SCHEDULE OF MATERIALS (materials not requiring drawings). — In estimating the materials to be used, the net amounts are figured, and allowances made where necessary for waste, rejection, etc.

BRICKWORK. — Amount in one bay as shown in the preceding table 805.88 cu. ft. + 50 cu. ft. in panel, not included, = 856 cu. ft. about.

No. of bays 10.5, end of building. $856 \times 61 = 52{,}216$ cu. ft.

$$\begin{array}{l} \underline{20.0} \text{ side of building.} \\ 30.5 \times 2 = 61 \text{ in all.} \end{array}$$

Contents of Walls	52,216 cu. ft.
Piers, 9 cu. ft. each, 95 in all . .	855 "
Stairway	4,310 "
	57,381 cu. ft.

57,381 × 24 = 1,377,144 bricks.
72,856, about 5 per cent.
1,450,000, to order.

STONE MASONRY. — About 50 cu. ft. of masonry per foot in length. Total length, 614 ft.

50 × 614	= 30,700	cu. ft.	= 1,137	cu. yds.
Piers	= 11,000	"	= 408	"
Extra under stairway	= 700	"	= 26	"
	42,400		1,571	

Specify dimensions if so required.

CEMENT used in foundation, $\frac{1}{6}$ of 42,400 = 7,067 cu. ft. of mortar.

$\frac{1}{3}$ cement = 2,355 cu. ft. = 678 lbs. of cement.
$\frac{2}{3}$ sand = 4,711 cu. ft. = 177 cu. yds. sand.

CEMENT and LIME for brickwork : —

1 barrel of lime will lay 1,000 bricks.
$\frac{1}{2}$ barrel of cement will lay 250 "
1,250 bricks.

1,400,000 ÷ 1,250 = 1,120, or 1,120 barrels of lime,
and 560 barrels of cement.

Sand for lime mortar : —

3 bbls. for every barrel of lime = 1,120 × 3 = 3,360 bbls.
$1\frac{1}{2}$ bbls. for every barrel of cement = 560 × 1.5 = 840 "
4,200 bbls.

4,200 bbls. = 15,120 cu. ft. = 560 cu. yds.

Totals — Cement, 1,238 bbls.
Lime, 1,120 bbls.
Sand, 740 cu. yds.

SOUTHERN PINE TIMBERS.

1	2	3	4	5
No. of Sticks.	Dimensions.	To Cut.	No. of Sides Planed.	Remarks.
740	7″ × 16′	16′ — 10″	3	(All ordered to cut one inch longer than finished length.)
152	7 × 16	17 — 6	3	
152	7 × 16	17 — 10	3	
76	7 × 16	18 — 2	3	
10	7 × 16	19 — 0	3	Near stairway.
10	7 × 16	19 — 6	3	

1,140, net amount. Order 20 extra sticks of long length, say ten 18′ — 0, and ten 19′ — 6″ long.

76	10″ × 14″	16′ — 10″	4	Roof timbers.
38	10 × 14	19 — 0	4	
2	10 × 14	19 — 6	4	

116, net amount. Order 4 extra sticks 19′ — 6″ long.

42	6″ × 8″	16′ — 10″	3	Wall timbers.
6	6 × 8	17 — 6	3	

48, net amount. Order 5 extra sticks 20′ — 0 long.

Spruce Plank, four inches thick, planed one side, grooved $\frac{3}{4}$ inch square, of widths not exceeding ten inches.

20,000 sq. ft. per floor × 5 = 100,000 sq. ft.

100,000 × 4 = 400,000 ft. board measure.

Add 10 per cent for waste, 440,000 ft.

Pine Roofing Plank, three inches thick, planed one side, grooved $\frac{3}{4}$ inch square, all to be 6″ wide,

About 22,000 sq. ft. × 3 = 66,000 ft. board measure.

Allow 10 per cent for waste, 6,600 = say 73,000 board measure.

Floor-boards of birch or maple, of uniform widths, not exceeding four inches.

100,000 sq. ft. Add 10 per cent. 110,000 ft. board measure.

Sheathing, in one story only, 18,000 sq. ft.

Add 10 per cent, and call it 20,000 ft. board measure.

SOUTHERN PINE COLUMNS.

7 ins. diam.,	38	to cut	13 ft.	4 ins.	long.		
	38	"	14 "	0	"	"	
	19	"	14 "	8	"	"	
	95						
8 ins. diam.,	95	"	8 "	1	"	"	
10 " "	95	"	8 "	1	"	"	
12 " "	95	"	8 "	1	"	"	
14 " "	95	"	8 "	1	"	"	

5th. SPECIFICATIONS AND CONTRACTS. — An accurate description of the materials to be used and work to be done is as important as the preparation of plans, and its clearness and fulness may save considerable expense and discussion in the final settlements. None the less important is the form of agreement between the two parties, owner and contractor. It should state clearly the conditions under which the work is to be done and paid for, and should be so drawn up as to cover both parties from injury to each other.

When any changes are made which will change the cost of construction, a new specification should be written for this change, and the contractor should agree to make the change at a reasonable sum.

SPECIFICATION FOR BUILDING NO. 5 MILL, U. S. COTTON MILLS.

BOSTON, MASS., March 1, 1886.

OLD BUILDINGS. — The contractor is to remove all old buildings and other obstructions on the site of the new mill. All old bricks may be cleaned and used again for backing up, and when cleaned, are to be stacked up as may be directed. All other old materials and rubbish to be removed from the premises, as well as all rubbish which may accumulate during the process of construction. The stone in foundation of old walls, if found of suitable sizes and shapes, may be again used in the new foundations.

EXCAVATION. — To do all excavation for basement story, foundations, piers, drains, and all other works requisite, amounting to about —— cubic yards, of which about —— cubic yards are to be retained for back-filling and grading, the remainder to be removed from the premises. To ram bottom of trenches if considered necessary for the reception of foundations, and to refill after laying of same, puddling or ramming the back-filling, and finally before leaving the work, to grade up to levels shown on the plans and sections, and to leave the ground clear and free from all useless soil or other material.

To keep the excavations free from water arising from whatever source, and to be responsible for all damage to work in hand and adjacent property. Should it be found necessary for the safety of the work and other property to drive sheet-piling, this shall be driven at least 5 feet below the bottom of the foundation. Shall be of 4-inch plank, grooved and splined, and for such work the contractor shall receive an extra sum, stated in the contract.

FOUNDATIONS. — All foundations for walls and piers to be of stone laid in cement mortar of the proportions one part cement to two of sand. The cement to be good and fresh, of satisfactory quality, the sand clean and sharp. The first course to be of large, flat stone of lengths and widths sufficient for 10 feet wide with not more than two stones in the width of course. The second course to be of stones of such width and length as to form a course of 7 feet wide with not more than two stones in width. Above this the stones are to be of reasonably large size and good shape for walls, as shown in plans. The wall is to be laid up equally smooth inside and outside.

PIERS. — All piers for pillars, and other brick below top of underpinning, to be of good, hard-burnt brick laid in cement mortar of the proportions one and one-half parts sand to one of cement, with close joints.

BASEMENT FLOOR. — That portion of floor in dark chamber is to be made of one foot of broken stone or clean, coarse gravel, covered with cement concrete, 4 inches thick, of the proportions 1 part cement, 2 parts sand, and 3 parts broken stone, or peb-

bles. The drains are to be one foot deeper than the rest, and filled in with broken stone, and located as shown on plans.

The remainder of the basement floor is to be of double 7×16 inch timbers, left rough and creosoted, the plank and top floor to be the same as described later for all wood floors. There must be at least two feet in the clear between the bottoms of timbers and ground.

EXPOSED BRICKWORK. — All exposed brickwork above underpinning for outside work must be of bricks well selected for color, and with full, sharp edges, and throughout of good hard brick of regular shapes, and where it is to show, the inside is to be laid equally well as the outside, with close joints and jointed: to lay not over 12 inches to 5 courses. All to be laid in mortar of the proportions, 1 barrel of lime, ½ barrel of cement, and 4 barrels of sand.

CEMENTS AND LIMES to be of some well-known brand, and to be of such quality as to meet the approval of the engineer in charge.

Sand to be clean and sharp, subject to same approval.

STONEWORK, except for foundation, must be of uniform shade, and free from flaws. All cut surfaces to be full; all exposed quarry-faces to be straight-split, with no hollows or projections beyond, and a part of such faces, of more than one inch, and must be so broken on their edges that the joints in the masonry are in the same vertical plane. All other exposed surfaces to be full throughout; beds and builds and end joints to be pointed to surfaces to allow for joints not exceeding ¼ inch. All stones must be of exact dimensions and finish indicated in the detail drawings, and no allowance is to be made in the cutting, for joints, except for joints between the stones; and for all such joints an allowance of ¼ inch shall be made.

CASTINGS. — Patterns will be furnished the contractor for cast-iron work, and all castings from these must be smooth and free from flaws, and finished as indicated in the detail drawings. All bearing-surfaces for pillars to be squared up. All pillars to be so cast that the cores shall be circular and the thickness of metal uniform. The ends to be squared up at

right angles to the axis of the pillar. Iron columns are to be used in all stories except upper story, where they will be wood.

WOODEN COLUMNS. — All wooden columns are to be of Southern pine, well seasoned, straight-grained, and free from knots; bored accurately through the centre, with a $1\frac{1}{2}$-inch hole, and to have $\frac{1}{2}$-inch vent-holes near the top and bottom; to be squared up at both ends at right angles to the axis of the column.

FLOOR TIMBERS. — All floor-timbers to be 7×16 inches, double Southern pine, bolted together with $\frac{3}{4}$-inch bolts, as shown on plans, with one-inch air-space between. Those for basement floor to be rough and creosoted, and for remaining floors, planed on three sides.

ROOF TIMBERS of Southern pine 10×14 inches, planed on 4 sides. Both floor and roof timbers to be straight-grained, free from knots, and well seasoned.

FLOORS. — All covered floors shall consist of 4-inch spruce plank, planed one side, grooved $\frac{3}{4}$-inch square, and of widths not exceeding 10 inches; covered with two thicknesses of tarred paper, and this covered with $\frac{7}{8}$-inch top flooring of birch or maple, planed one side, and jointed to uniform widths not exceeding 4 inches.

ROOF to consist of 3-inch Canada pine, planed one side, and heavy beaded, grooved $\frac{3}{4}$-inch square, and all 6 inches wide, covered with three thicknesses of tarred paper, and this covered with tin, put on with rib joints, and then painted (or six-ply New-England roofing, guaranteed for five years). In either case, to have copper gutters at eaves, around the entire building, made according to detail plans.

SHEATHING. — The under side of all floors, except basement, and that portion of first floor in picker-room to be sheathed with good pine mill-sheathing $\frac{1}{4}$-inch thick, of uniform widths, not exceeding 4 inches. Picker-room ceiling, including timbers, to be furred with wire netting, and plastered.

WINDOWS. — All windows must be made according to detail drawings. The runs, parting beads, and bands to be of South-

be made monthly, according to measurements and estimates of the engineer, of work satisfactorily done, twenty per cent of the amount of such estimates being reserved until thirty days after the completion and acceptance of said work.

In witness thereof, the corporate seal of the party of the first part, attested by the superintendent of the said mills, hath been affixed, and the party of the second part hath hereto set his hand and seal, the day and year first above written.

(Signed)

Sealed and delivered in the presence of (Signed) JOHN COBB.	WILLIAM SHERMAN. (Seal.) SAMUEL JACKSON. (Seal.)

PRECAUTIONS. — If there are any established building rules or regulations in the place where a mill is to be built, the engineer must inform himself of the same, and see that they are followed as closely as need be, and that those concerning the contractor should also be followed.

It is necessary to understand the lien laws of the district, in order that the owner or corporation may reserve enough of the estimated cost, and for long enough time, to cover any lien which workmen might place upon the work in case of default of the contractor to pay his men. It is also important to know what sort of liens may be placed for material furnished but not paid for by the contractor. Many of these finer points are matters of law, which vary in different places, but which should be distinctly understood for the place of operation.

The lien laws of Massachusetts can be found in chapter 191 of the Public Statutes.

[No. 42.]

N.E. COTTON MANUFACTURERS' ASSOCIATION.

PROCEEDINGS

OF THE

TWENTY-SECOND ANNUAL MEETING,

HELD AT BOSTON,

APRIL 27, 1887.

PRECEDED BY

CATALOGUE OF MEMBERS.

BOSTON:
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BOARD OF GOVERNMENT.

1887.

PRESIDENT.

J. S. LUDLAM . . . . . LOWELL, MASS.

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Office of the Association, Room 68, Sears Building, Boston.

MEMBERS OF THE ASSOCIATION.

1887.

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Benjamin F. Nourse.	Boston, Mass.

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John Cumnock . . .	Glasgow Co.	So. Hadley Falls, Mass.
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A. W. Danforth . .	Shanghai Cot. Cloth Mill Co.	Shanghai, China.
John W. Danielson .	Quinebaug Co.	Providence, R.I.
E. S. Davis	Continental Mills. . . .	Lewiston, Me.
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William P. Dempsey .	Demps Bleachery . . .	Pawtucket, R.I.
George Dexter . . .	Pepp ll & Laconia Co's. .	Boston, Mass.
William F. Draper .	. . . . .	Hopedale, Mass.
Joseph Dronsfield . .	F her Manuf. Co. . .	Providence, R.I.
David H. Dyer . . .	equechan Mills . . .	Fall River, Mass.
William A. Eastman .	Whitefield Mills	Newburyport, Mass.
Charles L. Eaton . .	. . . . .	Providence, R.I.
Isaac Eaton	. . . . .	Nashua, N.H.
Lawrence V. Elder .	Maginnis Cotton Mills . .	New Orleans, La.

Herbert R. Farnum	Bernon Manuf. Co.	Georgiaville, R.I.
Herbert Fisher		Taunton, Mass.
M. F. Foster		Milford, N.H.
Philip H. Fowler	Gloucester Gingham Mills	Gloucester, N.J.
J. Dwight Francis	Pontoosuc Manuf. Co.	Pittsfield, Mass.
Frank H. Fries		Salem, N.C.
Melville Gambrill	Arlington Mills Manuf. Co.	Wilmington, Del.
William B. Gambrill	Druid Co.	Baltimore, Md.
William Gammell, Jr.	Berkeley Co.	Providence, R.I.
A. J. Gardiner	Danielsonville Cotton Co.	Danielsonville, Conn.
James G. Garland		Biddeford, Me.
Richard Garsed	Wingohocking Mills	Philadelphia, Penn.
James A. Gary	Alberton Cotton Mills	Baltimore, Md.
Charles J. Goodwin	Indian Orchard Mills	Indian Orchard, Mass.
Alfred M. Goodale	Boston Manuf. Co.	Waltham, Mass.
David Gowdey		Providence, R.I.
Benjamin Greene	Cabot Manuf. Co.	Brunswick, Me.
Stephen Greene	Whitefield Mills	Newburyport, Mass.
William C. Greene	Thorndike Co.	Thorndike, Mass.
Frederick Grinnell		Providence, R.I.
Z. D. Hall		Lowell, Mass.
H. P. Hammett	Piedmont Manuf. Co.	Greenville, S.C.
J. F. Hanson	Bibb Manuf. Co.	Macon, Ga.
C. M. Harris, Jr.	Oakdale Shirt Manuf. Co.	Oakdale, Mass.
Frank Haskell	Westbrook Manuf. Co.	Saccarappa, Me.
William Hayes	Barker Mill	Auburn, Me.
Jefferson Higgins	Laurel Mills	Laurel, Md.
John H. Higgins	Forestdale Manuf. Co.	Slatersville, R.I.
Charles L. Hildreth		Lowell, Mass.
J. G. Hill	Lawrence Manuf. Co.	Lowell, Mass.
J. P. Hillard	American Linen Co.	Fall River, Mass.
Charles H. Hobbs	Slatersville Manuf. Co.	Slatersville, R.I.
John Holland	Cocheco Manuf. Co.	Dover, N.H.
Stephen Holman		Holyoke, Mass.
George W. Holt, Jr.	Monohansett Manuf. Co.	Putnam, Conn.
William Hooper	Atlantic Cotton Mills	Boston, Mass.
John Hopkinson	Mississippi Mills	Wesson, Miss.
Elisha H. Howard	Harris Manuf. Co.	Providence, R.I.
Henry S. Howe		Boston, Mass.
David L. Jewell	China, Webs'r & Pemb'ke M.	Suncook, N.H.
D. W. Johnson	Monadnock Mills	Claremont, N.H.

D. H. Johnston . .	Harmony Mills	Cohoes, N.Y.
Russell L. Jones . .	Ascutney Mills	Windsor, Vt.
Royal Kalloch . . .	Tennessee Manuf. Co. . .	Nashville, Tenn.
Roland R. Kelly . .	Wampanoag Mills . . .	Fall River, Mass.
Joseph H. Kendrick .	. . . . .	Providence, R.I.
Hervey Kent . . .	Exeter Manuf. Co.	Exeter, N.H.
John Kilburn . . .	Lawrence Manuf. Co. . .	Lowell, Mass.
H. C. Kimball . . .	Blackstone Manuf. Co. .	Blackstone, Mass.
A. F. Knight . . .	Bozrahville Co.	Bozrahville, Conn.
Ira F. Lawry . . .	Whittenton Manuf. Co. .	Taunton, Mass.
Harold Lawton. . .	Lapham's Mill	Centreville, R.I.
Frederick A. Leigh .	. . . . .	Boston, Mass.
Thomas I. Leiper . .	Irving & Leiper Manuf. Co.	Chester, Penn.
J. Ivers Lewis . . .	Uncasville Manuf. Co. . .	New London, Conn.
Charles W. Lippitt . .	Social Manuf. Co. . . .	Providence, R.I.
Henry Lippitt . . .	Social Manuf. Co. . . .	Providence, R.I.
Henry F. Lippitt . .	Globe Mill	Woonsocket, R.I.
Robert W. Lord . .	. . . . .	Kennebunk, Me.
Charles L. Lovering .	Whittenton Manuf. Co. .	Taunton, Mass.
Henry M. Lovering .	Whittenton Manuf. Co. .	Taunton, Mass.
William C. Lovering .	Whittenton Manuf. Co. .	Taunton, Mass.
J. S. Ludlam . . .	Merrimack Manuf. Co. .	Lowell, Mass.
Alvin S. Lyon . . .	Lowell Manuf. Co. . . .	Lowell, Mass.
W. H. Magee . . .	Berkeley Mill	Ashton, R.I.
Charles T. Main . .	Pacific Mills	Lawrence, Mass.
Charles H. Manning .	Amoskeag Manuf. Co. . .	Manchester, N.H.
Albert G. Martin . .	. . . . .	Northbridge, Mass.
Rufus A. Maxfield .	Nashua Manuf. Co. . . .	Nashua, N.H.
Thomas Mayor. . .	. . . . .	Providence, R.I.
Robert McArthur . .	Pepperell & Laconia Cos. .	Biddeford, Me.
W. E. McCoy . . .	Riverside Mills	Augusta, Ga.
Wm. H. McDavitt .	Appleton Co.	Lowell, Mass.
Charles D. McDuffie .	Manchester Mills. . . .	Manchester, N.H.
Fred. C. McDuffie. .	Everett Mill	Lawrence, Mass.
Frank M. Messenger .	Grosvenor Dale Co. . . .	North Grosvenor Dale, Conn.
James H. McMullan .	. . . . .	Biddeford, Me.
Timothy Merrick . .	Merrick Thread Co. . . .	Holyoke, Mass.
Oliver H. Moulton. .	Hamilton Manuf. Co. . .	Lowell, Mass.
J. Turner Morehead .	. . . . .	Leaksville, N.C.
W. H. Munroe . . .	Thistle Mills	Ilchester, Md.

Franklin Nourse . .	York Manuf. Co. . . .	Saco, Me.
E. H. Nutting . . .	Hooksett Manuf. Co. . .	Hooksett, N.H.
Warren M. Oswell .	Shirley Yarn Co.	Shirley, Mass.
John C. Palfrey . .	Manchester Mills. . . .	Boston, Mass.
Francis J. Parker . .	Monadnock Mills.	Boston, Mass.
Walter E. Parker . .	Pacific Mills	Lawrence, Mass.
John H. Parks . . .	NewBrunswickCottonMills,	St. John, N.B.
Theophilus Parsons .	Lyman Mills	Boston, Mass.
William D. Pennell .	Lincoln Mill	Lewiston, Me.
Haven C. Perham. .	. . . . .	Lowell, Mass.
John M. Pevey. . .	. . . . .	Lowell, Mass.
Moses Pierce . . .	Norwich Bleachery . . .	Norwich, Conn.
Thomas F. Plunkett .	Union Manuf. Co. . . .	N. Manchester, Conn.
H. L. Pratt	Bates Manuf. Co. . . .	Lewiston, Me.
Thomas Pray, Jr. . .	. . . . .	Boston, Mass.
J. E. Prest	Wampanoag Mills . . .	Fall River, Mass.
A. M. Pulsifer . . .	Barker Mill	Auburn, Me.
J. M. Pusey. . . .	Delaware Mills	Wilmington, Del.
M. W. Quinn . . .	Fiskdale Mills	Fiskdale, Mass.
T. G. Ramsdell. . .	Monument Mills	Housatonic, Mass.
Robert Redford . .	Arlington Mills	Lawrence, Mass.
James Renfrew, Jr. .	Renfrew Manuf. Co. . .	Adams, Mass.
Roscoe C. Reynolds .	. . . . .	Lewiston, Me.
John Rhodes . . .	. . . . .	Millbury, Mass.
F. H. Rice	. . . . .	W. Boylston, Mass.
Howard Richmond .	Crompton Co.	Providence, R.I.
A. Robeson	Fall River Print Works. .	Brookline, Mass.
William F. Salmon .	Lowell Hosiery Co. . . .	Lowell, Mass.
H. Saltonstall . . .	Pacific Mills	Boston, Mass.
Wm. G. Saltonstall .	York Manuf. Co. . . .	Boston, Mass.
Eugene H. Sampson .	Everett Mills	Boston, Mass.
Arnold B. Sanford .	Globe Yarn Mill	Fall River, Mass.
Benjamin Saunders .	Harbor Manuf. Co. . . .	Nashua, N.H.
J. H. Sawyer . . .	Newmarket Manuf. Co. .	Boston, Mass.
John Scott	Willimantic Linen Co. . .	Willimantic, Conn.
John C. Sharp, Jr. .	Canoe River Mills . . .	Taunton, Mass.
E. M. Shaw. . . .	Nashua Manuf. Co. . . .	Nashua, N.H.
Thomas S. Shaw . .	Suffolk Mills	Lowell, Mass.
Thomas C. Sheldon .	Sawyer Mill	Boylston, Mass.

George E. Sherman .	Valley Falls Co.	Valley Falls, R.I.
William F. Sherman .	Atlantic Cotton Mills . .	Lawrence, Mass.
Charles M. Shove . .	Granite Mills	Fall River, Mass.
Francis H. Silsbee. .	Pacific Mills	Lawrence, Mass.
James B. Siner . .	. . . . .	Malden, Mass.
Arva C. Slater . . .	Linwood Mills	Whitinsville, Mass.
Robert R. Smith . .	Greenwoods Co.	New Hartford, Conn.
S. S. Spencer . . .	Conestoga Steam Mills . .	Lancaster, Penn.
Wilbur A. Stiles . .	Victoria Mills	Newburyport, Mass.
Joseph Stone . . .	. . . . .	Boston, Mass.
Herman F. Straw . .	Amoskeag Manuf. Co. . .	Manchester, N.H.
Henry D. Sullivan. .	Naumkeag S. Cotton Co. .	Salem, Mass.
James O. Sweet . .	Ashland Cotton Co. . . .	Jewett City, Conn.
Edward P Taft . .	Ponemah Mills	Providence, R.I.
George P. Taylor . .	Lancaster Mills	Clinton, Mass.
Richard Thackeray .	Weetamoe Mills	Fall River, Mass.
E. A. Thissell . . .	. . . . .	Lowell, Mass.
Charles E. Thomas .	Clinton Manuf. Co. . . .	Woonsocket, R I.
Edwin R. Thomas .	Clinton Manuf. Co. . . .	Woonsocket, R.I.
E. W. Thomas . . .	Tremont and Suffolk Mills,	Lowell, Mass.
D. M. Thompson . .	Pontiac Manuf. Co. . . .	Providence, R.I.
Osmon B. Tilton . .	Jackson Co.	Nashua, N.H.
William E. Trainer .	Linwood Mills.	Linwood Sta., Penn.
C. H. Truesdell . .	. . . . .	Central Village, Conn.
Edmund E. Truesdell,	China, Webs'r & Pemb'ke M.	Suncook, N.H.
Albert F. Upton . .	. . . . .	Boston, Mass.
James Waring . . .	Narragansett Mills . . .	Fall River, Mass.
John Waterman . .	Warren Manuf. Co. . . .	Warren, R.I.
J. W. Wattles . . .	. . . . .	Canton, Mass.
T. B. Wattles . . .	Chicopee Manuf. Co. . .	Chicopee Falls, Mass.
George W. Weeks. .	Lancaster Mills	Clinton, Mass.
Henry F. West . .	Washington Manuf. Co. .	Gloucester, N.J.
Channing Whitaker .	. . . . .	Lowell, Mass.
W. J. Whitehead . .	V. Hudon Cotton Manuf. Co.	Hochelaga, P.Q.
Charles E. Whitin. .	Whitin Manuf. Co. . . .	Whitinsville, Mass.
Charles P. Whitin. .	Whitinsville Cotton Mills .	Whitinsville, Mass.
Harry T. Whitin . .	Rockdale Mill	Northbridge, Mass.
William H. Whitin .	Whitin Manuf. Co. . . .	Whitinsville, Mass.
A. N. Whiting . . .	Whiting Mills.	Oakdale, Mass.
William S. Whitney .	Pocasset Manuf. Co. . .	Fall River, Mass.
Theoph. W. Wilmarth,	Rockdale Mills	Northbridge, Mass.

Thomas Wilmarth .	Saunders' Cotton Mills. .	Saundersville, Mass.
George Wood . . .	Millville Manuf. Co. . .	Philadelphia, Penn.
William B. Wood . .	Continental Mills. . . .	Boston, Mass.
C. J. H. Woodbury .	. . . . .	Boston, Mass.
Daniel Wright . . .	Appleton Co.	Lowell, Mass.

Total number of Honorary Members 2
Total number of Active Members 232

CALL FOR MEETING.

BOSTON, April 5, 1887.

Dear Sir, — The stated Annual Meeting of the Association will be held at the Massachusetts Institute of Technology, Boylston Street, Boston, on Wednesday, April 27, 1887, at ten o'clock A.M., for the choice of officers for the ensuing year, and the transaction of such other business as may properly come before it.

By invitation of the Board, the following gentlemen will address the Association upon the topics named: —

Mr. JOHN T. HENTHORN of Providence, R.I., will present a paper upon THE RELATIVE MERITS OF COMPOUND AND SIMPLE EXPANSIVE ENGINES, WITH THE RELATIVE COST OF THE TWO SYSTEMS FOR DIFFERENT AMOUNTS OF POWER, TOGETHER WITH THE ANNUAL COST OF OPERATING THE SAME.

Mr. F. E. ALDRICH of Newton, Mass., will exhibit and describe the TRASK PATENT SPINDLE-STEP.

Mr. S. N. BROWN of Memphis, Tenn., will present and explain the use of WOODEN PULLEYS, in their adaptation to Cotton Mills.

By direction of the Board of Government,

AMBROSE EASTMAN,
Secretary.

PROCEEDINGS.

PURSUANT to the foregoing notice, the stated annual meeting of the Association was held at the Massachusetts Institute of Technology, on Wednesday, April 27, 1887, the President, Mr. J. S. LUDLAM of Lowell, in the chair.

The meeting was called to order shortly after ten o'clock, and the call was read by the Secretary.

The PRESIDENT. The twenty-second year of the existence of this Association having come to a close with this meeting, the first thing in order is to provide for a Board of Government for the coming year. It is customary to appoint a committee to select a Board of Government. What is your pleasure in respect to the appointment of the committee: shall it be done by ballot, or by the chair?

Mr. PARKER. I move that the committee be appointed by the chair. Carried.

The PRESIDENT. The chair appoints Messrs. HENRY F. WEST, DANIEL WRIGHT, HERVEY KENT, E. S. DAVIS, and J. IVERS LEWIS.

The committee thereupon retired for consultation.

The PRESIDENT. The Secretary will now read the reports of the Secretary and Treasurer.

The reports were read by the Secretary, and were by vote accepted and placed on file.

The PRESIDENT. The following-named gentlemen have been nominated for membership in the Association, and the Board of Government recommend them for election.

A. E. ADAMS, North Pownal, Vt.,
Agent North Pownal Manufacturing Company.
GEORGE W. BEAN, Lewiston, Me.,
Agent Androscoggin Mills.
ANDREW BORDEN, Fall River, Mass.,
Treasurer Merchants' Manufacturing Company.
JAMES M. BOURNE, Lowell, Mass.,
Agent Lowell Bleachery.
A. S. COVEL, Boston, Mass.,
Treasurer Tremont and Suffolk Mills.
CHARLES H. FISH, Chicopee, Mass.,
Agent Chicopee Manufacturing Company.
WILLIAM HOOPER, Boston, Mass ,
Treasurer Atlantic Cotton Mills.
W. D. MCDAVITT, Lowell, Mass.,
Agent Appleton Company.
JOHN TEMPEST MEATS, Plymouth, Mass.,
Godfrey Seamless Pocket Company.
FRANK M. MESSENGER, No. Grosvenor Dale, Conn.,
Agent Grosvenor Dale Company.
WILLIAM F. SHERMAN, Lawrence, Mass.,
Agent Atlantic Cotton Mills.
F. H. SILSBEE, Lawrence, Mass.,
Pacific Mills.
B. F. STEPHENSON, Waltham, Mass.,
Waltham Bleachery.

The question was put on the nomination of the gentlemen above named, and they were duly elected members of the Association.

The PRESIDENT. Gen. John M. Corse, Postmaster of Boston, has written a letter to the Secretary of the Association, saying that if the Association would care to indorse, as a body, the demand for a fast mail service between Boston and New York, he thinks it would have some weight in inducing the department at Washington to grant that service. As it is a matter of general interest to all of us, more or less, to improve the mail facilities of our particular district, it occurred to the Board of Government, that perhaps it would be a matter of possibly some importance to have an expression of opinion by the Association in regard to it. If any gentleman chooses to offer a motion,

it can, at all events, be put, and the sense of the meeting ascertained.

While you are thinking that over, it would not, perhaps, be amiss to say that the Board of Government has been a good deal exercised over the matter of providing some sort of entertainment for the members on the occasions of their meetings. This Association differs in a good many respects from the other associations of the country. I mean the professional associations, such as the Institute of Mechanical Engineers, or the Institute of Mining Engineers, or the Association of Civil Engineers. They have a very much larger membership, as a matter of course, and their meetings are largely and fully attended; and there is considerable inducement to attend their meetings, from the fact that at them you are likely to hear read papers of a good deal of importance. There is this marked difference, however, between this body and those associations: their work is more of the nature of public works than ours; and if a new method or machine happens to be one that cannot be protected by a patent, it must generally be given to the world at its first introduction into use. If, however, the author of the improvement cannot patent it, he can at least add some lustre to his professional reputation, and go on record as the originator of the improvement, by reading a paper on the subjoct at the meeting of his association. With the members of this Association it is different. If a man invents a new device or method that is patentable, of course, in time, we hear of it; but if it be not a patentable idea, he, naturally enough, in most cases keeps it to himself, and uses it only for the benefit of the company with which he is connected. And properly enough; for the keenness of the competition in our business quite justifies a man in keeping for his own use any improvement in machine or process he may invent. There are, of course, some subjects of general interest on which, from time to time, members can be induced to present their views; and in such cases the method adopted by the other associations would, without doubt, make these papers and the discussion upon them much more interesting than they have usually been

with us. With them the papers are prepared and printed, say, two months before the meeting takes place: notice is then sent to all the members that such papers will be read, and they are requested to inform the secretary if they desire to say any thing upon that subject. To all who express such a desire, a printed copy of the paper is sent, so that they may know the views set forth by the writer; and they come prepared to corroborate or attack his opinions, as they may agree or disagree with him.

Here we have it announced that a paper will be read on a certain subject; but you do not know what the writer proposes to say, until the paper is read at the meeting. And although you may differ greatly on every important point from the opinions set forth, you are not willing to on your feet and say so, off-hand, because you have not your facts and statistics, nor your argument so arranged that you are willing to go on record. The result is, the discussions of the papers read at our meetings do not give a fair representation of the thought of this body.

Another thing that has added very much to the interest of the meetings of the other associations, has been what they call topical discussions. They send notice to all members, at least six weeks before the meeting, that certain topics of professional interest are to be discussed; and one has an opportunity to prepare himself, if he cares to speak upon the subject. If he hears views stated at the meeting which are in opposition to his own experience and observation in the matter, he is prepared to get on his feet and combat those ideas, and give his reasons.

Now it must be clear to you, if these meetings are to be continued, that sufficient matter of interest must be provided to make them useful and enjoyable; and this can only be done, in default of contributions by the members, by procuring papers to be written by experts, outside of the association, on subjects of general interest to the members. This cannot always be done without some expenditure of money; and the question for you to decide is, whether you are willing, in the case of an insufficient supply of interesting and profitable material by members,

to authorize your Board of Government to provide the necessary material for an interesting and instructive meeting, at some cost to the Association. Some such changes will probably be necessary in the future proceedings of the Association.

Mr. PARKER. Mr. President, I would like to offer a resolution concerning the letter of the Postmaster of Boston, as follows: —

"*Resolved*, That it is the sense of this Association, that the increased mail facilities asked from the Post-Office department by the citizens of Boston and vicinity, are imperatively demanded by the business interests of New England; and that we earnestly second the efforts made in that behalf by the Postmaster of Boston."

The resolution was adopted.

The PRESIDENT. I beg to state in regard to the tables of figures referring to steam and its use in steam-engines, which will be found in your chairs, that they were sent around to you that you might follow Mr. Henthorn in the paper which he proposes to read this morning. It was thought desirable to give it to members in this shape, so they could keep pace with the speaker as he went on.

The PRESIDENT. — The committee appointed to nominate your officers for the ensuing year have returned the following list: —

President. — J. S. LUDLAM, Lowell, Mass.

Vice-Presidents. — WALTER E. PARKER, Lawrence, Mass.; RICHARD B. BORDEN, Fall River, Mass.

Directors. — O. S. BROWN, Salmon Falls, N.H.; HENRY F. LIPPITT, Woonsocket, R I.; WILBUR A. STILES, Newburyport, Mass.; STEPHEN N. BOURNE, Manchester, N.H; ROBERT MCARTHUR, Biddeford, Me; S. S. SPENCER, Lancaster, Penn.

Upon motion these officers were elected, by the secretary's casting one ballot, which represented the sense of the meeting.

The PRESIDENT. Mr. HENTHORN will now read his paper upon "The Relative Merits of Compound and Simple Expansive Engines, with the Relative Cost of the Two Systems for Different Amounts of Power; together with the Annual Cost of Operating the Same."

RELATIVE MERITS OF COMPOUND AND SIMPLE EXPANSIVE ENGINES FOR MILL PURPOSES.

By JOHN T. HENTHORN, Providence, R.I.

In presenting this crude paper to the Association, it is with a view of placing before the attention of manufacturers here assembled a few facts and figures bearing upon the relative economy of simple and compound engines for manufacturing purposes, while, at the same time, due consideration is given to the requirements for steam essential to finishing the manufactured product in the most economical manner.

This question, bearing upon the economy of fuel, is, at the present time, receiving more consideration from manufacturers throughout the country than has heretofore been given it, instigated very naturally by the result of the close competition and general condition of the market, which manufacturers have experienced during the past few years.

This matter of cost for fuel-supply, in connection with general running expenses, not only affects the proprietor in a marked degree, but indirectly the people in their employ, who are equally interested in the result which the question of cost per yard or per pound of the manufactured product has on the existence of an industry upon which the employees may be dependent.

The cost of production in all industries is divided between the different departments maintained to produce that article; therefore, while we may possibly be looking to the carding department as a field to work upon, it may be equally possible that the weaving and spinning departments are susceptible of changes that would materially reduce the cost of production. The same line of reasoning applies equally as well to the steam

department, although I fear many times this matter is lost sight of while engaged in other directions.

If we look at the records bearing upon this question fairly and from all points of view, I think it will be conceded that but little progress has been made during the past thirty years tending to an improvement in the economy of simple expansive engines.

And in view of this fact, we must look in the future for this improvement to the advantages offered for economy by the employment of a higher steam-pressure worked more expansively than is admissible in one cylinder, and carried out by the combined operation of two or more cylinders with the expansive energy of the steam equally divided between both.

To carry out practically these high ratios of expansion and pressures, implies a suitable proportion of cylinder capacity to pressure and work done, and means provided for reducing cylinder condensation by an efficient and safe system of steam-jacketing.

Non-condensing engines will probably reach their maximum efficiency at about 4½ to 5 expansions, while in simple cylinder condensing engines the equivalent is from 6 to 7, and the same steam-jacketed would be from 7 to 8, while in well-designed compound engines 20 expansions have been very successfully employed, as exemplified in the Corliss Engine at the Nourse Mill, and other engines from that builder.

GENERAL PRINCIPLES OF COMPOUND SYSTEM.

What is desirable in the steam department is, first, boilers that will generate dry steam easily and economically, and with furnaces so arranged as to successfully use the cheapest grade of fuel, and, second, an engine that will develop the power for driving machinery with the minimum amount of fuel, cost for attendance, general supplies, etc. At the same time, however, the system should recognize the requirements necessary for a proper working condition of the material in process, in the mill.

To accomplish this desired economical result, when power is the main factor to be provided for, it is first necessary to pro-

vide ample cylinder capacity in the engine, in order that the steam may be worked more expansively than has heretofore been admissible, in simple condensing engines.

This is accomplished, by first allowing the steam at a high pressure to enter the small cylinder of the system, and, after performing its proportionate amount of work, it then passes to the condensing or large cylinder, where the measure of expansion is prolonged therein to the extent of expanding until we have a pressure at the end of the stroke of about 8 pounds above a perfect vacuum, when it is finally allowed to pass to the condenser. In triple-expansive engines, the steam from the high-pressure cylinder passes to the intermediate cylinder of larger capacity, and thence to the condensing cylinder of still larger capacity, and, finally, to the condensing apparatus as before.

This additional cylinder capacity implies at once an increase in the first cost of the engine, from the fact that necessarily larger cylinders are to be employed to overcome a given amount of work, and implying an increase in their weight to overcome the strains to which they are to be subjected. Secondly, the boilers are constructed of heavier material, and of such workmanship as to enable them to safely carry a working steam-pressure beyond what has heretofore been ordinarily considered ample for general mill-purposes, in order to better allow this measure of expansion to be carried out in the engine, to which they may be connected. This, of course, again suggests an increase in the first cost of the boilers for the plant. And finally, the appliances should be such as to assist in the economical and harmonious working of the whole system ; and at the same time the arrangements for the connections in the mill should be such as to economize at all points in the connected mill, and thus reduce the losses of heat throughout to a minimum.

The advantages to be derived in working steam expansively, in two or more cylinders, from a high pressure carried in the boiler to that below the atmosphere, lies in the fact, that, for a given ratio of expansion, the range of temperature between the maximum pressure entering the first cylinder, and minimum pressure as it leaves the last or condensing cylinder, is equally

divided between the number of cylinders forming the system; with the result of a marked reduction in the cylinder condensation by such a subdivision of the range of temperature of the expanding steam, and at the same time a corresponding reduction in the strains upon the working parts, and in the friction of the machinery.

Were it not for this ever-present practical element, — i.e, cylinder condensation, — and it were feasible to construct a cylinder of perfectly non-conducting material in which to work the steam expansively, and thus impart none of its heat to surrounding bodies, it would then be immaterial, as to economy, theoretically, whether one, two, or more cylinders were employed in a system for a given ratio of expansion. But when we come to look at the practical side of the question, the matter of cylinder condensation together with that of the strength of engine-framing, strains upon pins, shafts, etc., and friction of mechanism, it is of sufficient importance to warrant the introduction of one or more cylinders, according to the working-pressure carried, and so proportioned that the work done shall be equally distributed between them, and at the same time reduce to a minimum amount the rate of condensation of the incoming steam, by the reduction of the range in temperature of the steam entering and leaving each successive cylinder, with the result of a marked increase in the efficiency and economy of the engine.

NOT ALWAYS ADVISABLE TO COMPOUND.

The mere fact that an engine is so arranged and designed as to work the steam successively through two or more cylinders does not carry with it the sometimes implied impression that such a form of engine must of necessity be of the most economical type; although we must admit, that such a principle applied to that specific detail of construction would indicate a material advance in its economical working when compared with the same general construction running as a simple condensing engine.

It is foreign to the nature of facts to take an acknowledged

inferior principle in the construction of an engine, and hope that by compounding, or by the addition of a second cylinder, to make amends for a faulty design, and thus place it upon an equal footing with a system of machinery of proper construction that is fully as efficient when running under simple expansion only.

Therefore, I may say, that all compound engines are not economical when considered in the sense of this paper, or from a point of view to be judged from by manufacturers. And further, there are many compound engines running to-day, — notably employed for public water-service, — that are inferior to the large class of automatic cut-off simple condensing engines that are to be found in well organized manufacturing establishments.

It is essential, as in all matters of this nature, that a well-devised principle of construction, so arranged as to utilize the full expansive measure of the steam admitted to the cylinder of the engine, should of necessity be present, to thus hope for even an economical simple condensing engine. And it is only by a further continuance in the carrying-out of that correct principle that will justify the greatest economy looked for in compound engines.

THEORETICAL VALUE OF STEAM EXPANSION.

To illustrate the theoretical value of working steam expansively in cut-off engines as a comparison with an engine following full stroke, I have prepared the following table.

TABLE 1.

TABLE SHOWING THE THEORETICAL POWER DUE TO THE USE OF THE SAME QUANTITY OF STEAM, WHEN USED UNDER DIFFERENT RATIOS OF EXPANSION.

Point of Cut-off.	Number of Expansions.	Horse-power.
Full Stroke	0	100.
1-2 "	2	169.3
1-3 "	3	209.8
1-4 "	4	238.6
1-5 "	5	260.9
1-6 "	6	279.1
1-7 "	7	294.5
1-8 "	8	307.9
1-9 "	9	319.7
1-10 "	10	330.2
1-11 "	11	339.7
1-12 "	12	348.4
1-13 "	13	356.4
1-14 "	14	363.9
1-15 "	15	370.8
1-16 "	16	377.2
1-17 "	17	383.3
1-18 "	18	389.0
1-19 "	19	394.4
1-20 "	20	399.5

Now, for the moment, we will take as an example an engine in operation, where the steam is allowed to follow the full length of the stroke, and thus derive no benefit from the expansive force of the steam admitted, and assume that the power developed is, theoretically, 100-horse power.

If, in place of this state of affairs, we so arrange the speed of the engine, and so set the cut-off as to allow the steam to follow one-half stroke previous to cutting off from the boiler-supply, we shall then find that the same quantity of steam previously used in the same engine when working full stroke gives under this new condition 169.3-horse power, which may be developed from this simple fact of two expansions, as exemplified in the above table.

Again, if we so arrange our speed and cut-off as to allow for three expansions, or at one-third cut-off, we then find that we have 209.8-horse power, that may be developed from the same

quantity of steam that was previously used in the full-stroke engine working without expansion, or a gain of over one hundred per cent.

By following the table given, it will be seen that working steam under twenty expansions, as applicable in first-class compound engines for mill-purposes, about four times the amount of power may be developed from the same quantity of steam if the latter had been used at full stroke in a non-expansive engine. Or, we may say, that about one-third additional power may be derived in a compound engine, from the same quantity of steam, over that for simple condensing engines working at one-seventh cut-off.

ADAPTATION OF COMPOUND ENGINES.

A compound system of engines, like all other classes of machinery, is better adapted for the motive-power of some particular branches of industry than for others, from the fact that a special work requires a different mode of treatment, that will thus be in keeping, and, at the same time, recognize the requirements covering, not only the driving of the machinery, but also the finishing of the fabric in the different departments. And in justice to the manufacturer and others looking to the subject of the most desirable power for driving the machinery, while at the same time furnishing means to economically finish the product of the mill, it is not well to unreservedly recommend the compound system of engines as being the most suitable for all cases that may arise.

When we consider the question of maritime traffic, we then encounter several very important items, the first of which is to reduce the cost for the supply of fuel to a minimum, which, secondly, implies a reduction in the working-force of the fire-room.

While we are accomplishing the above, we are also at the same time providing for additional cargo-carrying capacity of the vessel in proportion to the space saved from coal-bunkers, due to the difference in fuel between the two systems; which signifies a material increase in the revenue of the vessel. And

here I may say, that a decrease of one-half pound of coal per horse-power per hour may give a large trans-Atlantic steamer a saving of about 400 tons of coal for a single round trip. Then, again, there are questions of a practical nature, bearing upon the general strength of the whole machinery, and the unison in the strains upon the pins, shaft, etc., while working, that are such as to lead an engineer to a decided preference for this system of machinery for that service.

These facts, I may say, are the predominating factors that decide the question, in the minds of ship-owners, as to the comparative value of the compound system of engine over others, and are so apparent as to need no comment from me, further than to say that its adaptability to this service has justified its wonderful progress, and, I may add, now the universal motive-power for ocean-going vessels.

When we come to the question of the motive-power for woollen-mills having dye-houses attached, compound engines as a rule should not be entertained, on the ground that all available exhaust steam from the engine required to drive the machinery is, usually more valuable for heating-purposes in the dye-house than would justify the economy in its use for power alone, by passing it through a second cylinder running condensing. While, if this was done, the required amount of steam for heating-purposes would necessarily come direct from the boiler.

For this work, assuming for a moment that we had an engine that would develop a horse-power for a pound and three-quarters of coal per hour, including banking, starting, etc., for a week's time, and, at the same time, an equal amount of steam required for the engine was necessary for heating-purposes in the different departments, we should then not only have to supply the amount of coal necessary for the engine, but also that for generating steam for heating-purposes as well.

Whereas, if in place of our compound engine working economically for power alone, we implant an ordinary non-condensing engine, and pass the steam required for the dye-house or for heating-purposes through the engine, we shall then find that this

exhaust steam is equally as available for heating-purposes after the power is abstracted from it for driving the machinery as before. In other works, where large quantities of steam are required for heating-purposes, as building, drying, heating water, etc., the most economical engine by far for driving the machinery is a high-pressure or non-condensing engine; as, for such a service, a first-class compound engine would prove an uncalled for expenditure of capital.

When we consider the most advantageous system of motive power for the production of cotton fabrics, we have then a different element to deal with. There it is found we have but a limited amount of steam for heating-purposes to be provided for, covering only the requirements for steaming and slashing yarn and boiling sizing throughout the year, and for heating the mill during the cold weather, which, as a whole, requires but a small fraction of the steam generated for motive power.

This quantity of steam for heating-purposes may be readily and economically furnished from the receiver between the two cylinders of the engine of the compound system under a moderate pressure, say eight pounds.

For this branch of industry, and others covering like conditions, I should recommend most emphatically the adoption of the compound principle of modern construction as the motive-power, with a view of reducing to a minimum the cost of maintaining that department.

And it is with an assured feeling of adaptability that it will accomplish that purpose, which has mainly instigated the preparation of this paper for the financial consideration of manufacturers.

COMPOUND ENGINES FOR WATER WORKS.

As a just tribute to the founder of the automatic cut-off engine, whose name is ever cherished wherever there is found the hum of industrial mechanism, I am sure our many friends of this representative textile society will concede to this fair name, George H. Corliss, the honor of first introducing as a crowning effort of his lifelong labors a system of machinery which stands to-day a monument of his just endeavors.

In this compound system of machinery, whether employed for public water-service, or for the motive-power of private textile industries, is found the general principles conceived at the commencement of his eminent career, but in a stage of development which placed it beyond competition at the time of its installation.

If we refer to the record below, Table No. 2, of his compound pumping-engine located at Pettaconset, Providence, R.I., in 1882, for the year 1885, we there find as a yearly record, taking into account all fuel used in the pumping-station, which, of course, includes banking and starting fires, 106,137,000 foot-pounds of duty, which is equivalent to 1.69 pounds of fuel per horse-power per hour, on an efficiency of work done, the same being 91 per cent of the indicated horse-power.

TABLE 2.

RECORD OF THE CORLISS ENGINE AT PETTACONSET, FOR THE YEAR 1885.

Total Number of Hours run	4,375.67
Number of Days in which Engine run	286.00
Daily Average Number of Hours run	15.30
Total Number of Gallons pumped	1,633,285,468.00
Daily Average Number of Gallons pumped	5,710,788.00
Total Fuel consumed in Pounds	2,244,690.00
Daily Average consumed in Pounds	7,848.57
Total Amount of Wood consumed in Pounds . . .	44,000.00
Daily Average Amount of Wood consumed in Pounds,	153.85
Average Head in Feet	176.20
Per cent of Ashes, etc., to the Total Fuel	15.15
Average Duty per 100 Pounds of Total Fuel (without Allowance for Ashes, etc.)	106,137,000.00
Fuel per Hour, per Indicated Horse-power, based on Total Fuel and 91 per cent Friction	1.69
Gallons pumped per Pound of Fuel	723.00

As a similar type of compound engine, it is well to refer, in this connection, to the pioneer engine on that system from the same noted builder, and installed for the public water-service at Pawtucket in 1878, whose several yearly records in foot-pounds of duty, i.e., the number of pounds of water raised one foot high with the expenditure of 100 pounds of total fuel used; together with the equivalent duty expressed in pounds per hour

per indicated horse-power of engine, as an average of the several yearly performances, is as follows. (See Table 3.)

In this same table (No. 3) the duty in foot-pounds, together with its equivalent amount of fuel per hour per indicated horse-power, is given, based upon the amount of fuel used while pumping only.

TABLE 3.

SHOWING THE SEVERAL YEARLY RECORDS OF THE CORLISS PUMPING-ENGINE, LOCATED AT PAWTUCKET, R.I.

YEAR.	Average Pumping Time per Day.	Average Duty based on Fuel used for starting, pumping, and banking.	Fuel per Hour, per Ind. Horse-power, based on Fuel used for starting, pumping, and banking.	Average Duty based on Fuel used while pumping only.	Fuel per Ind. Horse-power, per Hour, based on Fuel used while pumping only.
			Pounds.		Pounds.
1880	–	–	–	–	–
1881	12.50	106,480,860	1.702	150,306,074	1.211
1882	16.41	115,105,309	1.582	142,946,422	1.274
1883	–	–	–	–	–
1884	13.09	109,233,967	1.667	147,651,803	1.232
1885	13.70	110,489,446	1.648	145,628,244	1.242
1886	14.21	112,481,734	1.619	135,160,717	1.346

The record in detail for the eleven months ending Nov. 30, 1886, is also given in Table 4, below, wherein is found, as an average duty, 112,481,734 pounds of water raised one foot high per 100 pounds of coal, calculated on total coal used for starting, pumping, and banking (no deduction for ashes and cinders), or an equivalent of 1.619 pounds of fuel per indicated horse-power per hour, upon a basis of work done as being 92 per cent of the indicated horse-power. These two percentages of friction were often practically determined for these respective engines while experiments were in progress.

In these two examples of pumping-engines just cited, the daily average running time was 15.30 and 14.21 hours, respectively, which exceed those forming a day's labor in mill practice, which fact would slightly modify the coal consumption were the same engines to run under like conditions but ten hours

day, or mill practice, on account of the amount of fuel used for banking and starting fires being proportioned to less hours of active service of the engine.

TABLE 4.

SHOWING IN DETAIL THE RECORD OF THE CORLISS PUMPING-ENGINE, LOCATED AT PAWTUCKET, R.I., FOR ELEVEN MONTHS, ENDING NOV. 30, 1886.

Total Number of Hours pumping	3,660.14
Average Pumping-time per Day	14 21
Average Revolutions per Minute	45.96
Total Number of Gallons pumped	416,126,133.00
Average Head against Pump in Feet	274 18
Fuel for starting Fires	91,691.00
Fuel for pumping	719,588.00
Fuel for banking	53,495.00
Total Fuel for starting Fires, pumping, and banking,	864,774.00
Average Number of Gallons pumped per Pound of Coal consumed, for starting, pumping, and banking,	481.19
Average Duty in Pounds of Water raised One Foot High, per Hundred Pounds of Coal; calculated on Total Coal used for starting, pumping, and banking; no Deduction for Ashes and Cinders . . .	112,481,734.00
Fuel per Hour, per Indicated Horse-power, based on Fuel used for starting, pumping, and banking, and 92 per cent Friction	1,619 pounds.

COMPOUND ENGINES FOR MILLS, ETC.

As a strictly comparable result bearing upon the textile industries which you have at heart, I may cite the record of the Nourse Mill engine at Woonsocket, R.I., whose experimental record for a period of seven days I had the honor of determining, wherein all fuel burned under the boilers during that time, which includes banking and starting fires, is included in the record for work done with an average result of 1.626 pounds of fuel per hour per horse-power developed by the engine, without any deduction whatever for ashes or clinker, the fuel being ordinary merchantable coal, stove size, such as found in the market the day previous to the test.

These interesting facts are given in detail in Table 5 for each day's run, and in Table 6 a general summary for the period covered by the test is given.

The engine above referred to was built by Mr. George H. Corliss, and is of the tandem type, with cylinders 20 inches and 36 inches diameter, with a stroke, common to both, of 6 feet. The rated capacity of each pair of cylinders is 500-horse power, or 1,000-horse power for the complete plant. The fly-wheel is 30 feet in diameter, with a face of 110 inches, so arranged as to accommodate four belts. The nominal speed of the engine is 57½ revolutions per minute.

Each cylinder is steam-jacketed, — the high-pressure cylinder directly from the boiler, and the low-pressure cylinder from the receiver.

Steam for warming the mill during the winter months, vapor-pots in the weaving-room, steaming-box, and slashing, is drawn from the receiver between the two cylinders at a pressure of about 8 pounds, and, where possible, all drips are returned to a tank located in the boiler-room, and from thence, by connection with the pumps, it is delivered to the boilers.

TABLE 5.

Result of a Seven Days' Trial of the Corliss Compound Engine at Nourse Mill, commencing Oct. 15, and ending Oct. 22, 1884.

	Starting Fires.			Coal while running.	Wood used during Running Time.	Value of Same at 40 %.	Total New Fuel fed to Furnace each Day.	Cinders used during Day.	Total Fuel fed to Furnace each Day.	Cinders found at End of Day.	Total Fuel used.	Running Time.	Fuel used per Hour.	Indicated Horse-power.	Fuel, per Hour, per Indicated Horse-power.	Average Revolutions.
	Wood.	Value at 40 % of Coal.	Coal.													
Wednesday, Oct. 15, 1884,	1,000	400	2,647	6,838	200	80	9,965	-	9,965	863	9,102	11 h. 44 m.	775.76	498.93	1.55	56.96
Thursday, Oct. 16, 1884 .	833	333	2,535	7,200	-	-	10,068	-	10,068	685	9,383	11 h. 41 m.	803.13	496.37	1.61	57.10
Friday, Oct. 17, 1884 . .	30	12	2,800	7,200	-	-	10,012	-	10,012	730	9,282	11 h. 40 m.	795.64	495.09	1.60	57.08
Saturday, Oct. 18, 1884 .	-	-	3,200	3,600	-	-	6,800	1,671	8,471	729	7,742	9 h. 44 m.	795.41	483.80	1.64	57.46
Monday, Oct. 20, 1884 . .	800	320	3,200	7,200	-	-	10,720	-	10,720	742	9,978	11 h. 42 m.	852.82	509.46	1.67	56.84
Tuesday, Oct. 21, 1884 . .	10	4	3,200	6,904	-	-	10,108	-	10,108	717	9,391	11 h. 40 m.	804.98	504.24	1.59	56.99
Wednesday, Oct. 22, 1884,	-	-	3,200	4,300	30	12	7,512	3,018	10,530	455	10,075	11 h. 41 m.	862.36	501.94	1.71	57.17
Totals and Averages for 7 Days	2,673	1,069	20,782	43,242	230	92	65,185	-	-	-	-	79 h. 52 m.	812.38	499.00	1.62	57.10

TABLE 6.

General Summary of Seven Days' Trial of Nourse Mill Engine, commencing Oct. 15, and ending Oct. 22, 1884.

Fires were started on Clean Grates, Wednesday, Oct. 15, 1884.

Wood, 2,903 Pounds; Equivalent Value in Coal at 40 %	1,161 pounds.
Coal for starting Fires	20,782 "
Coal used while running	43,242 "
Total Amount of Fuel fed to Furnaces	65,185 pounds.
Deduct Cinders found at End of Run, 455 Pounds, estimated at 80 % Value of New Coal	364 "
Total Fuel used during the 7 Days	64,821 pounds.
Running Time	79 h. 52 m.
Fuel per Hour	811.6 pounds.
Average Indicated Horse-power from 636 Cards	499.1
Fuel, per Hour, per Indicated Horse-power	1.626 pounds.
Average Revolutions per Minute	57.1
Percentage of Ash and Clinker	11.9

PRACTICAL STANDARD OF COAL CONSUMPTION PER HORSE-POWER PER HOUR.

The care which was taken in the endeavor to arrive at the facts of the efficiency of this steam-plant at the Nourse Mill, and the prolongation of the experiment, together with the corroborating facts just cited in connection with the pumping-engines, justify me, I think, in taking 1.7 pounds per indicated horse-power, including all fuel, as a standard for this class of machinery, for comparison between this and the existing type of simple condensing engines now in operation by the members of this society, with a view to demonstrate the feasibility from a financial point of view, of the economy to be derived by their substitution or by compounding their present system of machinery, and thus place them upon an economical basis.

Simple condensing engines, where they are not influenced by the gentle action of connected friendly water-wheels, require as a most favorable result, when we consider banking and starting fires, for a week's time, 2.55 pounds of fuel per hour per indicated horse-power; and I am inclined to believe that the many members present, especially those from Fall River, will concede this a fair estimate, and possibly below their individual experience. I shall, therefore, upon that assumption, use this figure as a basis for comparison as to the cost of maintaining the simple condensing engine with that required for the compound system.

When the engine at Pawtucket was on its first season's work, a two weeks' contract-test was made, which I had the honor of recording, the condition there being such as to require ten hours running time of the engine per day, omitting the intervening Sundays, and the duty to be estimated on the total fuel used during each twenty-four hours of that period, which, of course, included banking and starting fires.

This daily record is given below in Table 7, covering the duty in foot-pounds per hundred pounds of total fuel; and, at the same time, as an interesting comparison, the duty is also given when based on the fuel used while the engine was pump-

ing only, thus leaving out that used for banking and starting fires.

The corresponding amount of fuel per hour per horse-power for these two conditions is also given, or an average for the two weeks' running, based on total fuel, of 1.745 pounds.

A certainly very creditable comparison for the case at hand; and when based upon the amount of fuel used during the running time of the engine only, the average for the same period is 1.361 pounds per hour.

TABLE 7.

RECORD OF TWO WEEKS' TEST OF PAWTUCKET PUMPING-ENGINE MADE IN 1878.

DATE.	Average Pumping Time per Day.	Average Duty based on Fuel used for starting, pumping, and banking.	Fuel per Hour, per Ind. Horse-power, based on Fuel used for starting, pumping, and banking.	Average Duty based on Fuel used while pumping only.	Fuel per Ind. Horse-power, per Hour, based on Fuel used while pumping only.
Tuesday, Aug. 6 .	10	103,191,770	1.764	130,013,951	1.400
Wednesday, Aug. 7 .	10	105,877,530	1.720	133,367,951	1.365
Thursday, Aug. 8 .	10	105,973,950	1.718	131,170,034	1.388
Friday, Aug. 9 .	10	102,021,290	1.784	132,212,793	1.377
Saturday, Aug. 10 .	10	106,132,830	1.715	134,774,696	1.351
Monday, Aug. 12 .	10	96,500,311	1.886	132,674,651	1.372
Tuesday, Aug. 13 .	10	107,183,480	1.699	135,438,435	1.344
Wednesday, Aug. 14 .	10	105,359,104	1.728	133,593,400	1.363
Thursday, Aug. 15 .	10	105,864,460	1.720	133,293,626	1.366
Friday, Aug. 16 .	10	108,021,020	1.685	136,755,307	1.331
Saturday, Aug. 17 .	10	108,591,650	1.677	133,639,991	1.362
Monday, Aug. 19 .	10	98,345,727	1.851	136,781,763	1.331
Averages	–	104,357,654	1.745	133,696,834	1.361

In this connection, allow me to say that this latter condition, wherein is recognized only the amount of fuel actually used while the engine is in operation, and from which is estimated the efficiency of an engine, is entirely misleading when the manufacturer comes to make a comparison of the yearly coal consumption with a guaranty framed on that basis, and the only apology in offering it herewith, is to show the necessity of recognizing that important item, banking and starting, to which further reference will be made.

COMPARATIVE COST OF SIMPLE AND COMPOUND ENGINES.

When considering the matter of the proper selection of engines, the natural inquiry would be, What is the difference in the first cost between a first-class condensing engine and one of the compound type; and the yearly saving between the two systems, as an offset for the additional price to be paid? This question is answered clearly by Table 8, for engines varying from two hundred and fifty to fourteen hundred horse power of each system, together with the yearly operating expenses necessary for their respective fuel-supply.

And when the comparison is made between the difference in first cost, and the saving effected during one year in the operation of the compound engine, we find that practically the additional cost is justified by the gain realized during that period.

TABLE 8.

SHOWING THE COST OF SIMPLE AND COMPOUND ENGINES FOR POWERS FROM 250 TO 1,400-HORSE POWER, TOGETHER WITH THE COST FOR THEIR RESPECTIVE FUEL SUPPLY FOR 309 DAYS OF 10 HOURS EACH.

	HORSE-POWER OF ENGINE.										
	250 H. P.	300 H. P.	400 H. P.	500 H. P.	600 H. P.	700 H. P.	800 H. P.	900 H. P.	1,000 H. P.	1,150 H. P.	1,400 H. P.
STEAM-JACKETED CONDENSING ENGINES.	Single.	Single.	Single.	Single.	Single.	Pair.	Pair.	Pair.	Pair.	Pair.	Pair.
Size of Engine	23″ × 60″	26″ × 60″	30″ × 60″	32″ × 60″	34″ × 72″	28″ × 60″	30″ × 60″	30″ × 60″	32″ × 60″	32″ × 72″	36″ × 72″
Diameter and Face of Main Driving Pulley	20 ft. × 31″	22 ft. × 33″	25 ft. × 39″	25 ft. × 52″	26 ft. × 60″	27 ft. × 66″	27 ft. × 74″	28 ft. × 80″	30 ft. × 84″	30 ft. × 100″	30 ft. × 115″
Approximate Cost of the Machinery complete with Condensing Apparatus, Boilers, Flues, Pumps, Heaters, Piping, etc.	$10,780 00	$12,830 00	$15,830 00	$18,480 00	$22,340 00	$28,010 00	$31,110 00	$32,940 00	$37,010 00	$42,040 00	$50,268 00
Approximate Cost of the Foundations for Engines and Boilers	1,675 00	2,010 00	2,680 00	3,350 00	4,020 00	4,690 00	5,360 00	6,030 00	6,700 00	7,705 00	9,380 00
Total Cost of the Machinery and Foundations ready for Steam	12,455 00	14,840 00	18,510 00	21,830 00	26,360 00	32,700 00	36,470 00	38,970 00	43,710 00	49,745 00	59,648 00
Yearly Cost for supplying the above Engine with FUEL for 309 Days of 10 Hours each, and Coal at $4.75 per Ton of 2,240 lbs., on a Basis of 2.55 lbs. per Indicated Horse-power, and including all Fuel	4,177 18	5,012 62	6,683 49	8,354 37	10,025 24	11,696 11	13,366 99	15,037 86	16,708 74	19,215 05	23,392 23
STEAM-JACKETED COMPOUND ENGINE. Steam, 125 lbs. Pressure.	Single.	Single.	Single.	Single.	Single.	Pair.	Pair.	Pair.	Pair.	Pair.	Pair.
Size of Engine	13 & 26 × 60″	15 & 30 × 60″	15 & 30 × 72″	17 & 34 × 72″	18 & 36 × 72″	14 & 28 × 72″	15 & 30 × 72″	16 & 32 × 72″	17 & 34 × 72″	18 & 36 × 72″	21 & 42 × 72″
Diameter and Face of Main Driving Pulley	20 ft. × 31″	22 ft. × 33″	25 ft. × 39″	25 ft. × 52″	26 ft. × 60″	27 ft. × 66″	27 ft. × 74″	28 ft. × 80″	30 ft. × 84″	30 ft. × 100″	30 ft. × 115″
Approximate Cost of the Machinery complete with Condensing Apparatus, Boilers, Flues, Pumps, Heaters, Piping, etc.	$12,380 00	$14,580 00	$19,400 00	$21,520 00	$25,254 00	$31,077 00	$34,150 00	$37,900 00	$42,190 00	$48,238 00	$57,300 00
Approximate Cost of the Foundations for Engines and Boilers	2,050 00	2,460 00	3,280 00	4,100 00	4,920 00	5,740 00	6,560 00	7,380 00	8,200 00	9,430 00	11,480 00
Total Cost of the Machinery and Foundations ready for Steam	14,430 00	17,040 00	22,680 00	25,620 00	30,174 00	36,817 00	40,710 00	45,280 00	50,390 00	57,668 00	68,780 00
Yearly Cost for supplying the above Type of Engine with FUEL for 309 Days of 10 Hours each, and Coal at $4.75 per Ton of 2,240 lbs., on the Basis of 1.7 lbs. per Hour, per Indicated Horse-power, and including all Fuel used	2,784 78	3,341 73	4,455 65	5,569 56	6,683 47	7,797 39	8,911 30	10,025 21	11,139 13	12,809 99	15,594 78
Difference in the Yearly Cost of Fuel Supply between the Two Types of Engines	1,392 40	1,670 89	2,227 84	2,784 81	3,341 77	3,898 72	4,455 69	5,012 65	5,569 61	6,405 06	7,797 45
Additional First Cost of the Machinery and Foundations for a Compound Engine over a Simple Steam-jacketed Condensing Engine of Like Power	1,975 00	2,200 00	4,170 00	3,790 00	3,814 00	4,117 00	4,240 00	6,310 00	6,680 00	7,923 00	9,132 00

COMPARATIVE COST OF COAL IN DIFFERENT LOCALITIES, IN RELATION TO SIMPLE AND COMPOUND ENGINES.

The farther away our factories are located from the coal-fields, the more we have to pay for fuel delivered in the mill-yard, and consequently the more necessity of economizing in the steam-department by the employment of the compound system of engine. And this fact suggests the comparison and value of the two systems when located in Boston, Providence, New Bedford, Fall River, Lowell, Lawrence, Worcester, Clinton, Willimantic, Lewiston, and Manchester, — or eleven different manufacturing localities.

In this connection, if we refer to Table 9, on the comparative cost of supplying condensing and compound engines of 1,000-horse power with fuel, when located at Manchester, N.H., where coal has been estimated for that locality at $5.75 per ton of 2,240 pounds, delivered in the mill-yard, we find, that, for 1,000-horse power for 309 days of 10 hours, $20,226 is the cost of fuel for a first-class condensing engine, while for the same power and conditions, $13,485 represents the cost for the fuel of a compound engine; or, in other words, a yearly saving of $6,741 between the cost of fuel for the two systems, representing a capital of $134,823 at 5 per cent interest, or still further, a yearly investment of 13.3 per cent on the total cost of the machinery and foundation, as given in Table 8.

The basis of comparison between the two systems, as given in this table, are on the assumption that 2.55 and 1.7 pounds of fuel are used respectively, including starting, running, and banking, as previously referred to.

TABLE 9.

COMPARATIVE COST OF SUPPLYING CONDENSING AND COMPOUND ENGINES OF 1000-HORSE POWER WITH FUEL PER YEAR OF 309 DAYS OF 10 HOURS EACH.

	LOCALITY.					
	Boston.	Providence, R. I., New Bedford, Mass., Fall River, Mass.	Lowell, Mass., Lawrence, Mass.	Worcester, Mass., Clinton, Mass., Willimantic, Mass.	Lewiston, Me.	Manchester, N.H.
Cost per Ton, of 2,240 lbs., of Lackawanna Coal delivered in Mill-yard	$4 75	$4 50	$5 25	$5 50	$5 00	$5 75
Pounds of Coal used for 1000-Horse Power for a Year of 309 Days of 10 Hours each, taking the Total Fuel used for starting, running, and banking, as a Basis for estimating a Duty of 2.55 lbs. of Fuel per 1-Horse Power for First-class Condensing Engines	7,879,500	7,879,500	7,879,500	7,879,500	7,879,500	7,879,500
Tons of 2,240 lbs. on above Basis per Year,	3,517.93	3,517.93	3,517.63	3,517.63	3,517.63	3,517.63
Cost of above Fuel at Different Localities,	$16,708 74	$15,829 33	$18,467 55	$19,346 96	$17,588 15	$20,226 37
Pounds of Coal that would be used under Similar Conditions if Engine was a First-class Compound, Duty estimated at 1.7 lb. per Hour, based on Total Fuel . . .	5,253,000	5,253,000	5,253,000	5,253,000	5,253,000	5,253,000
Tons, of 2,240 lbs., on above Basis per Year	2,345.08	2,345.08	2,345.08	2,345.08	2,345.08	2,345.08
Cost of above Fuel at Different Localities .	$11,139 13	$10,552 86	$12,311 67	$12,897 94	$11,725 40	$13,485 21
Difference in Cost of Coal between the Two Systems at Different Localities	5,569 61	5,276 47	6,155 88	6,449 02	5,862 75	6,741 16
At 5 per cent Interest, this Saving of Coal would represent a Capital of	111,392 00	105,529 00	123,117 00	128,980 00	117,255 00	134,823 00
Interest on the Total Cost (as per Table, No. 8, $50,390) of Compound Engines with their Boilers, Foundations, etc., complete, set up and ready for Belts, represented by the Yearly Saving of Fuel between the Two Systems.	11.0 %	10.4 %	12.2 %	12.7 %	11.6 %	13.3 %

COMPOUNDING EXISTING ENGINES.

No definite line of action may be laid down as to the best arrangement in the matter of detail for compounding existing engines, as the circumstances as to location, pressure, and amount of work to be performed and provided for, might be such as to suggest, were it a pair of engines, the substitution of one new cylinder of the desired capacity, or, possibly, the addition of two smaller cylinders working on the same piston-rod and in unison with that of the old cylinders.

Were the former plan carried out, much of the details of construction belonging to the valve-gear of the old cylinder could be made to do good service on the new, and thus materially reduce the cost of making such changes by a well-conceived plan of operation, and also without much lost time in so doing.

However, as this matter of the most economical and judicious arrangement of details is necessarily of a special or of an individual nature, a word now as to the benefits that may be expected from making such changes.

It is scarcely possible to conceive of a dozen engines of like size, employed in as many different mills, that are running under like conditions as to power. Some may be employed on a light service, some on their rated capacity, while the remainder may be driven to an extent far beyond their rating, which naturally calls for an exceptionally late cut-off. Equal results from these varying conditions could not reasonably be expected, if compounded, were they still employed to overcome the same amount of power, from the fact of the varying degrees of expansion carried out in the cylinders of the different cases under comparison; and as the economy is mainly due to the ratio of expansion carried out in the two cylinders, it signifies that engines when over-loaded to commence with, although they may to advantage be compounded, would not be as economical as others where more cylinder capacity to work done is to be had, to thus better provide for the expansive force of the steam admitted. Neither can we, in justice to manufacturers,

say that results equal to new engines may be obtained by compounding their present machinery, from the fact, that, in providing a new motive-power, a more ample provision is usually made in the cylinder capacity, to thus utilize the full extent of this economical measure of expansion.

SAVING BY COMPOUNDING EXISTING ENGINES.

I can say, however, that it is reasonable to expect a saving of from 15 to 20 per cent of the fuel now used by the engines employed as the motive-power of cotton-mills; and to more forcibly call to the attention of the gentlemen present as to the advantages which it is reasonable to expect by compounding existing engines, when considered from a financial point of view, reference is made to the following table (No. 10), wherein this saving expressed in dollars per year for a varying amount of power is given for engines from 200 to 1,500 horse power.

The said table is based on a relative saving of one-half pound of fuel per hour per indicated horse-power, for the two systems, and the value of the coal is estimated at $4.50 per ton of 2,240 pounds.

TABLE 10.

Showing the Yearly Saving by compounding Existing Engines, based upon a Saving of about 20 per cent, or One-half Pound of Fuel per Hour, per Indicated Horse-power, and Fuel $4.50 per Ton of 2,240 lbs. Running Time 3,090 Hours.

Horse-power.	Saving in Fuel per Year of 309 Days of 10 Hours each.	Horse-power.	Saving in Fuel per Year of 309 Days of 10 Hours each.
200	$620 75	850	$2,638 22
225	698 35	875	2,715 82
250	775 94	900	2,793 41
275	853 54	925	2,871 00
300	931 13	950	2,948 60
325	1,008 73	975	3,026 19
350	1,086 32	1,000	3,103 79
375	1,163 92	1,025	3,181 38
400	1,241 51	1,050	3,258 98
425	1,319 11	1,075	3,336 57
450	1,396 70	1,100	3,414 17
475	1,474 30	1,125	3,491 76
500	1,551 89	1,150	3,569 36
525	1,629 49	1,175	3,646 95
550	1,707 08	1,200	3,724 55
575	1,784 68	1,225	3,802 14
600	1,862 27	1,250	3,879 74
625	1,939 87	1,275	3,957 33
650	2,017 46	1,300	4,034 93
675	2,095 06	1,325	4,112 52
700	2,172 65	1,350	4,190 12
725	2,250 25	1,375	4,267 71
750	2,327 84	1,400	4,345 31
775	2,405 44	1,425	4,422 90
800	2,483 03	1,450	4,500 50
825	2,560 63	1,475	4,578 09
		1,500	4,655 69

In this connection the question will naturally arise, What will be the cost of making such changes per horse-power? And in reply thereto, from a careful estimate of such work, I would say, that $4 per horse-power would cover all of the expenditure therefor; and if we take as an example an engine of 1,200-horse power, the cost of compounding such machinery would amount to about $4,800; whereas the saving in fuel by one year's service would, by reference to Table 10, amount to $3,724, or approximately pay for making such changes in about sixteen months' service, the advantages resulting from making such changes being obvious.

In regard to compounding existing engines employed as the motive-power of cotton industries, I believe a very substantial benefit may be derived by so doing for a comparatively small outlay; and, in fact, realize the cost of making such changes by a short period of its operation, and thus in turn reduce materially the cost of production of the manufactured product.

I cannot conceive of a more substantial reward for the conscientious consideration of manufacturers than is offered by the foregoing suggestion to compound their existing engines, and thus place their steam plant upon an economical basis.

VALUE OF FUEL FOR BANKING.

Incidentally, reference has been made to the importance of recognizing the quantity of fuel used for starting and banking fires, when estimating the efficiency of an engine, in order that its commercial value may be established for comparison by manufacturers. They, as a class, are interested in the yearly cost of maintaining a specific department, and what matters it to them whether the engine is guaranteed to develop an indicated horse-power for 14 or 16 pounds of water per hour, or 1.5 pounds of fuel, during the time that the engine is running only, when the cold fact remains, that from 15 to 20 per cent additional fuel is required to be paid for by them to get the fires under way daily before the engine may be started, which, under that form of a contract, is ignored entirely.

Were it possible to devise a scheme by which this fuel could

be gratuitously furnished, it would then little matter, and would possibly justify that form of contract; but until such a charitable institution is found, manufacturers should, in justice to their interests, recognize all fuel which is required to be furnished and paid for by them in order that a given power may be maintained and developed intermittently for a stated period, covering at least a week's time.

Regarding engine tests of the character previously referred to, wherein the fuel used while the engine is running only is recognized as a basis for estimating the efficiency of an engine, I may say in this connection, that, in my judgment, little dependence can be placed upon a personal judgment of the condition of a furnace-fire when viewed at the commencement of a test, as a basis for comparison with its condition ten hours hence, as it is, as we all know, susceptible of a division of assumed well-founded opinions. And to thus eliminate all such important factors possible, I contend that the only condition which should be countenanced by manufacturers in the framing of conditions to govern such tests, is to start upon clean grates, and to weigh all fuel that is used in the furnaces (which, of course, includes wood and coal for starting and banking fires) for an extended period of not less than one week, as a basis for estimating the efficiency of any engine.

Were this done, the question as to the amount of fuel necessary to start fires would not enter for argument, and I am under the impression that it would be much less than would otherwise be considered necessary for the same purpose, if that element was provided for by an agency outside of the parties interested in the test of the engine.

With the efficiency of an engine determined by a contract test of the form recognizing *all* fuel used, manufacturers would then have a practical basis to work upon, which to them is of far greater importance than the mere matter of theoretical considerations and assumptions.

TRIPLE EXPANSIVE ENGINES.

A marked improvement in compound engines has been made in marine practice during the past two or three years, by the addition of an intermediate cylinder between the high and low pressure, with the result of a corresponding reduction in the intermittent strains upon the main shaft; and, at the same time, a substantial benefit is realized in the more economical working of the system by such addition, from the fact that a greater range of expansion is available.

As the size and power of ocean-steamers has now reached such enormous proportions in order to meet the demands of the travelling public, the propeller-shaft of such steamers has, I believe, reached the practical limit of their diameter and endurance, and relief in the near future may be looked for only through a greater division of the power for propulsion by the employment of the triple or quadruple expansive system of engine operating twin-screws.

I believe I am not far from the truth when I say that the propeller-shaft of the present ocean-going steamer is the weakest place in the machinery. And to favor this vital part in all ways possible, fully as much consideration has been given by the designers of the machinery to the matter of reducing the strains of rotation emanating from the steam cylinders, by a proper division of the work to be done in three or more cylinders, as the mere question of fuel has received; although the additional cylinder of the triple-expansive system likewise produces a most satisfactory gain in the economy.

COMPARISON OF TRIPLE-EXPANSION MARINE ENGINES WITH COMPOUND ENGINES ASHORE.

When we come to compare the records of long voyages of practically continuous steaming, obtained from the marine triple-expansion engine even though working under 140 pounds' steam pressure, with that obtained from the two-cylinder compound engine ashore, working at 125 pounds' steam-pressure, and at a serious disadvantage regarding active service of fires, — we find,

when we consider the question of fuel only, no substantial facts suggest the necessity of three cylinders for economically utilizing a pressure of 125 pounds. As a comparison with the compound engines previously referred to, Tables 11 and 12 are given, covering the two-cylinder compound and the triple-expansive engines as applied to marine service. It is obvious, that the question of starting fires and banking during a long voyage is comparatively a small item in the fuel account, and can therefore be considered continuous steaming, the conditions of such a voyage being the most favorable to develop the greatest possible economy in the system of machinery employed. And as for a nearly comparable result to continuous steaming, we may refer to the last column of Table 3, wherein the fuel used per horse-power per hour, based on the fuel while pumping, as recorded for the several yearly duties of the Pawtucket pumping-engine is given, and may be of interest as a comparison of what is accomplished as a year's record with a two-cylinder compound engine employed on shore-duty, as compared with the triple-expansive engine afloat.

Table 11 gives the average working for a period of over three years, of three steamers of approximately the same dimensions and deadweight carrying capacity, belonging to Messrs. Steel, Young, & Co.; the steamship "Para" being fitted with triple expansion, while the two sister ships were fitted with compound engines of the same build.

If, now, we take the average coal-consumption per day of the two steamers having compound engines, as a basis, we learn that the steamship "Para" will run for about 26 per cent less fuel than the two former vessels, notwithstanding the fact that a higher rate of speed is attained by the steamer having the compound system.

In Table 12, where the average results are given for approximately similar boats, on a voyage from England to Java and return, even greater results are reported as the relative saving between the two systems.

TABLE 11.

COMPARATIVE RESULTS FROM THREE SIMILAR STEAMERS WITH COMPOUND AND WITH TRIPLE EXPANSION ENGINES.

	Name of Steamer.		
	Ingram.	Wandle.	Para.
Length, Feet and Inches . . .	257′ 6″	257′ 6″	257″ 6″
Breadth, Feet and Inches . . .	34′ 6″	34′ 6″	34′ 6″
Draught, Feet and Inches . . .	18′ 10½″	18′ 6½″	19′ 4″
Deadweight carried in Tons . .	2,310	2,203	2,398
Type of Engine	Compound.	Compound.	Triple.
Diameter of Cylinders			19″ 35″ 53″
Stroke			33″
Revolutions			62
Indicated Horse-power, High . .			201
Indicated Horse-power, Intermediate			213
Indicated Horse-power, Low . .			206
Indicated Horse-power, Total .	270	580	620
Boiler Pressure in Pounds . . .	75	75	150
Speed, Knots per Hour	8½	8½	9
Coal consumption, Tons . . .	13 3 4	14	10¼
Coal consumption per Hour, per Indicated Horse-power	2.25	2.25	1.88

TABLE 12.

COMPARATIVE RESULTS FROM THREE STEAMERS WITH COMPOUND AND WITH TRIPLE EXPANSION ENGINES.

	Name of Steamer.		
	Fellingay.	Padang.	Jacatra.
Length, Feet and Inches . . .	286′ 2″	300′ 0	314′ 0
Breadth, Feet and Inches . . .	35′ 0″	37′ 0	37′ 9″
Draught, Feet and Inches . . .	20′ 3″	21′ 9″	21′ 6″
Deadweight carried, Tons . . .	2,600	3,000	3,300
Type of Engine	Compound.	Compound.	Triple-Ex.
Boiler Pressure, Pounds . . .	70	76	140
Speed, Knots per Hour	9	9½	10
Indicated Horse-power	660	790	890
Coal consumption, Tons . . .	15½	18	13½
Coal consumption per Hour, per Indicated Horse-power . . .	2.19	2.13	1.41

In these cases, using, as before, the daily average coal-consumption on the two steamers having compound engines as a basis, we there find, on the steamship "Jacatra," wherein is a system of triple-expansion engines, that about 34 per cent less fuel is used, a very substantial result when we come to consider the extra cargo-carrying capacity resulting from the decreased space required for coal-bunkers necessary to cover a voyage.

The same material saving is reported for the Orient Company's steamship "Lusitania," after the engines were converted from compound to triple expansion.

The original engines had cylinders 58 inches and 103 inches diameter, and a stroke of 48 inches. The cylinders were replaced by 60 inches and 96 inches diameter, with an additional cylinder of 36 inches. The revolutions of the engines were 76 per minute.

Previous to the change in the system, 52 tons of Welsh coal is reported as the daily consumption for a voyage from London to Sydney. After the changes to the triple-expansion system were made, the coal-consumption is reported to have been reduced to 37 tons, when the ship travelled at the same speed as before the change, or a reduction of about 30 per cent, the advantages effected by the change being obvious.

GENERAL DEDUCTIONS.

From the foregoing I am of the opinion that a well-designed two-cylinder compound engine for manufacturing purposes is of ample capacity to successfully utilize the measure of expansion available with a working steam-pressure of 130 pounds; and from that point up to 165 pounds, a triple-expansive engine would be justified to thus more evenly distribute the strains upon the working parts of the engine, while admitting, at the same time, of a greater range of expansion, and to which in turn is largely due a greater degree of economy.

It now becomes me to thank this representative Society of the Textile Industry for the honor and privilege of addressing you, accorded me through the courtesy of your able president; and while I assure you that it is with many misgivings as to its

incompleteness, there remains the one redeeming fact of a mutuality of interest for the promotion of a more economical steam-plant for our manufacturing industries.

The PRESIDENT. If any members present would like to ask Mr. Henthorn any questions with respect to the very interesting paper which he has read this morning, now is the time.

Mr. WEST. Mr. President, I do not know that I have any questions to ask, but I have listened to the reading of the whole document with a great deal of interest, and I think it important that it should be preserved, and, if in order, I would move that it be incorporated in our next report.

The motion was carried.

The PRESIDENT. Mr. Henthorn's remarks about marine engines call to mind one point of similarity between a steamship and a cotton-mill; which is, that both are compelled to economize space as much as possible. In that connection I was much struck with some boilers I saw on board the Cunard steamer "Etruria." I found there some boilers, cylindrical boilers, thirteen feet in diameter, on which they were carrying one hundred and ten pounds of steam. That is so opposed to shore-practice, that I was very much struck by it; and, as the matter of economy of space is sometimes almost as important in a cotton-mill as it is on board a steamship, I thought I would mention them. If any of you gentlemen are contemplating an addition to, or re-arrangement of your boiler plant, you may possibly find it worth your while to make a new departure and try something of this sort. These boilers were fired at each end, and the products of combustion were taken out at the centre: there were eight furnaces in each end, and the furnaces were stepped up in two rows. Another thing that has very often struck me, in these days of high pressures, is the almost entire absence of accidents at sea from the bursting of boilers and steam-pipes. Of course, occasionally a ship is destroyed; she is gone, nobody knows where; and it is generally attributed to ice. But there is no record, so far as I know, of any serious accident on board any ocean-steamer from the bursting of a boiler or a steam-pipe. And when you consider the extraordinary service, the

jumping and thumping and banging they have to undergo, it is a very remarkable fact, and high testimony to the thoroughness of their workmanship; and it would seem that any practice they follow is worthy of great attention.

If nobody seems inclined to ask Mr. Henthorn any questions, the next subject that will be brought up for your consideration is the Trask patent spindle-step, by Mr. Aldrich of Newton, Mass.

THE TRASK PATENT SPINDLE-STEP: EXPLANATION OF ITS MECHANISM AND ADVANTAGES.

By F. E. ALDRICH, Boston, Mass.

I WOULD call your attention this morning to the Trask patent spindle-step. In the pamphlets, which, together with sample steps, are now being distributed to you, we have taken the liberty of quoting from the "Textile Manufacturer," published in Manchester, Eng., an article showing the necessity for a device of this kind; and have pointed out briefly the advantages which the Trask step possesses over those now in general use. Referring to spindle-foot steps, and the wasteful methods of lubrication now in vogue, this journal says: —

"The steps, as usually constructed, seem to have been especially devised to waste the oil by throwing it out as speedily as possible. Of course, it must not be forgotten that the method, of which complaints may now justly be made, served moderately well twenty-five or thirty years ago, when the speeds were twenty-five or thirty per cent less than at present.

"The velocity at which spindles were then worked did not throw off nearly so large a proportion of the lubricant as it does now. The rage for high speeds and the results attained have rendered it imperatively necessary to endeavor to improve the construction of the step on more than one account. First, it is desirable to secure more perfect lubrication, and so diminish the wear and tear of spindles, bolsters, and steps, and also reduce the power to drive them. Second, a regard to economy should lead to an endeavor to save the oil now wasted, and, at the same time, prevent the dirt which is the result of such waste, and further diminish the risk of fire from the saturation

of the floorings caused by the oil flying off the spi[illegible]ergo, it [illegible] which has often led to fires from spontaneous combustio[illegible]ugh- [illegible] high speeds of ring-frame spindles have only been rendere[illegible]ac- [illegible] sible by the invention of better methods of lubricating t[illegible] [illegible] and now, for many purposes, it is incontestable that they h[illegible] [illegible] passed the mule spindle a long way in the power of production.

"Makers of mules, in order to keep up as well as possible, have successively accelerated the speed of the spindles, but, singular to say, have altogether neglected the means by which its rival has been enabled to outstrip it, and has been rendered almost perfect. It is well known that fluids in a state of rapid circular movement have a tendency to assume a concave, or cup-like, form, the maximum point of depression being in the centre. This rapid movement is imparted to the oil in the foot-step by the revolution of the spindle, and hence it will be seen that the oil, of necessity, soon begins to overflow the cup all around its edges.

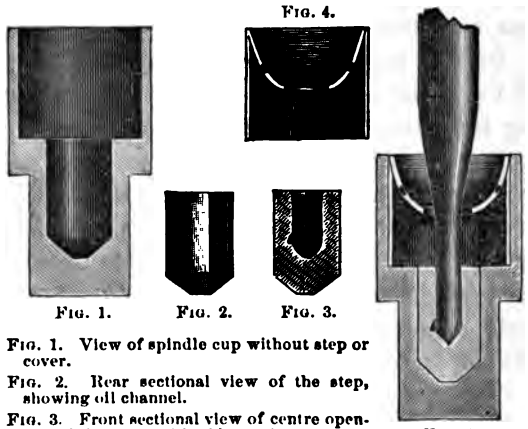

Fig. 1. View of spindle cup without step or cover.
Fig. 2. Rear sectional view of the step, showing oil channel.
Fig. 3. Front sectional view of centre opening of the step, with side perforations extending to the oil channel.
Fig. 4. Ventilated concave sleeve, or cover.
Fig. 5. Step complete with portion of spindle.

"There is another outlet for it. Immediately the spindle commences working, the oil begins to travel up the foot until it attains a point at which it is thrown off by the centrifugal force generated by the revolution of the spindle. 'Any one can easily demonstrate the fact to his satisfaction, that all spindles of these classes, when in operation, are constantly pumping the oil from the steps and throwing it off in every direction, by holding a sheet of clean white paper on edge between two spindles, or in close proximity to the spindle and step, and

noting how quickly it becomes soiled by the oil. Of course, the higher the rate of speed at which the spindles are run, the more rapidly the oil will be thrown off and the step become dry.' "

The Trask step, as may be seen by the diagram shown, consists of an oil-chamber, having a step within its base, and a concave, ventilated cover, so arranged as to prevent the escape of any oil, or any waste or fly from getting into the step or chamber. The cup serves as a reservoir for the oil, and at the bottom part where it enters the rail, is chamfered out so as to allow the step to be firmly fixed therein, below the level of the top surface of the head. The step provides a bearing for the base of the spindle. On the outer side this step is provided with grooves or oil-channels having horizontal perforations extending from the chamber into the interior of the step, near the bearing point of the spindle; so that, as the oil is drawn from the step by the rapid revolution of the spindle, these channels at the outer side of the step return the oil through the horizontal perforations to the base of the spindle again; thus insuring constant and thorough lubrication. At the top we have provided a concave ventilated cover, so arranged as to prevent the escape of the oil, and also to prevent any waste or fly from getting into the step. To demonstrate the utility of this device, we have had steps in continuous use in a mill for over a year; and when, accompanied by a mill-engineer, I examined them a short time since, I found the chambers entirely free from waste, and the oil, which had been put in twelve months previously, to be in good condition, and sufficient in quantity to last several months longer.

From our experience with them, and the results obtained, we suggest the following advantages which a mill would derive from the use of these steps: —

First, Perfect lubrication of the spindles at all times; hence, no dry or squeaky spindles.

Second, Saving in power required to run the spindles.

Third, Less wear on the spindles, because of perfect lubrication.

Fourth, A very material saving of oil, — a large proportion of the oil now being absolutely thrown away.

Fifth, Saving of time and labor over the present method of oiling and cleaning mules and frames.

Sixth, Clean rails, frames, and floors; and consequently, diminished risk of fire from the present oily conditions.

The PRESIDENT. Any discussion upon the Trask patent step is now in order, if any gentleman wishes to ask Mr. Aldrich any questions, or has any view to express.

Mr. KENT. I would like to inquire for my own information, and possibly for the information of others, if Mr. Draper claims any royalty on this step.

Mr. DRAPER. I certainly do not at the present time claim any royalty. This is the first time I have ever seen the step; I have never seen the patent upon which it is based, or any thing of the sort; and I am always ready to own up as far as I know.

Mr. BIRKENHEAD. I do not believe Mr. Draper knows what he has got, but I am satisfied he has got that.

The PRESIDENT. You will notice that Mr. Draper qualified his remark by saying, "at the present time."

The PRESIDENT. The next number on our programme seems to be that of Mr. S. N. Brown of Memphis, Tenn., with some wooden pulleys, which he proposes to present and explain to us.

WOODEN PULLEYS.

Remarks of Mr. S. N. BROWN of Memphis, Tenn.

Mr. President and Gentlemen: Your board of directors have very kindly invited me to make an exhibit of wooden pulleys here to-day, and say a word in regard to them. And I must confess, that it is with a great deal of diffidence that I come before you, because I am not accustomed to speaking to an audience of experts in applied mechanics. The subject on which I am to speak to you is a pulley which was superseded during long years of trial with something which promised to give better results. Now, for a long time, wooden pulleys have been practically driven from the market by cast-iron pulleys; and yet, for the last six years wooden pulleys, modified by such changes as many years of experiment and careful observation have suggested, have again made their appearance; they are to-day having a large sale, and many manufacturers, on many kinds of work, give them the preference over iron pulleys.

Now, what advantages have wooden pulleys over iron for the transmission of power? As I understand, they are, first, very much lighter in weight; and by their use you reduce the load that is carried on your lines of shafting by some 50 to 70 per cent. This, we claim, greatly lessens the friction on your bearings, and it seems to me it must save you a corresponding amount of power. Again, makers of wooden pulleys claim, that, with like tension of belt, you can transmit more power from wood than from iron. Just what that ratio is, I am not prepared to say; we think we have good authority for giving the ratio at 30 per cent. Haswell, in his book on engineering, gives

the ratio of friction obtained by belts worn over wooden pulleys as 47, as against 27 when worn over cast-iron pulleys, — a large percentage in favor of wood. And the Franklin Institute of Philadelphia indorses this statement by giving a percentage of at least 33 per cent in favor of wood. Now, gentlemen, if this be true, then the use of wooden pulleys allows the use of much slacker belts than iron. This will not only reduce the friction caused by tight belts on your shafting, but it will add much to the life of the belt, and that sometimes is a very important consideration, especially in large establishments.

Again, the tendency, as I understand it, to-day is towards fast-running shafting; and I think there is not one of you but will freely admit that a wooden pulley properly constructed can be safely run at a much higher velocity than an iron one.

Thus, in brief, gentlemen, I have stated the advantages that are urged by the makers of wooden pulleys from their use. With your kind permission I wish now to show you one of the latest forms of wooden pulleys upon the market to-day. I have a little model here which I can explain, showing the construction, and I have a few of the larger ones here. If you wish to look at them, I shall be glad to show them to you. This is a wooden pulley. The rim is bridged on a line between the arms; and the distinguishing feature of it from all other pulleys in the market, as it seems to me, is the method of applying it to the shaft. This pulley is fitted to the shaft by a hickory bushing; it is set in place, and you get your grip by compression from bolts. This pulley is made of whitewood segment pieces fastened together; the arms are of ash, bolted together; and the cushion is of hickory, as I have said. Now, what we claim for that pulley is, that it is lighter, from 50 to 70 per cent, than iron. The advantage of the bushing system is, that you are enabled to change the bore of your pulley to suit twenty different sizes of shafts, without expense or delay; and, with ordinary speed and use, the shafting is not marred at all. Another great advantage is, that by fastening it on the shaft in that way, your pulley is running perfectly true and on a perfect plane all the time. You can see at once,

that, the tighter you close these bolts, the better the pulley will run.

I do not know that I need to occupy your time any longer in regard to this. It is very simple in construction, and you can all see the points on which we rely. I wish to say, in conclusion, that I thank you for your kind attention, and for the invitation to speak here and give an exhibition. The house I represent appreciate your courtesy, all the more because they happen to be located south of what was once known as Mason and Dixon's line. (Applause.) As a New England man myself, I wish to say, that the fashion has not quite gone by of thinking that whatever progress is made in the mechanical arts must, of necessity, make its progress north of that line. I know you will all join with me in expressing our best wishes for the prosperity of that great section of our country, and that you will all take pride in the efforts that are being made to develop its great natural resources. I would simply say, that if I can answer any question that any of you wish to ask, or if I can give you any information in regard to these pulleys, I should be pleased to do so at any time.

Mr. BIRKENHEAD. I would like to ask a question or two in regard to these pulleys. Can you explain why the friction of a belt on a wooden pulley is greater than it is on an iron one? Of course, it is admitted that it is so, but have you any idea why?

Mr. BROWN. No, sir; I am not versed enough in mechanics to answer that.

Mr. BIRKENHEAD. Will you answer another question. What would one of these pulleys weigh, say a 7-inch pulley? — a pulley 7 inches in diameter, and with a 3-inch face.

Mr. BROWN. None are made less than 9 or 10 inches in diameter. I have given you the weight of some of those.

Mr. BIRKENHEAD. The reason I asked the question is this (producing a package containing an iron pulley). Here is a pulley which I thought I would bring down; I have had it some time. We carry spindles in our pockets sometimes; but

this is pretty large, and I could not get it in, so I brought it in this way. I do not wish to depreciate the value of wooden pulleys, because I think they are a good thing; but I think it is a pity if anybody does dig out an idea, and nobody knows about it, that some future generation should go and get a patent on it; so I thought I would bring this here. There is a pulley that has got a cast-iron spider in the centre and a cast-steel face to it. It is not of a kind to bend as some other iron pulleys are, and it is a pulley that is very easily made. This can be welded. Cast steel of this description is welded. Shovels are welded of this kind of steel. It can be welded by a trip-hammer which comes down just so far and no farther, and gives just the right thickness. After it is welded, the spider being turned up, it is placed upon the spider, and you have a pulley all turned up ready to put on. Now to fasten it, I simply have to split the bushing, you see, then you put that on to the shaft, then put the pulley on, — of course you can slip it along, — then give the bushing a little tap and you have it fastened on there. Now, to show whether this runs true or not, I turn the pulley on a shaft (illustrating). If there was a little oil on there, you would be able to see it, perhaps. That pulley weighs two pounds, it is 7 inches in diameter and has a 3-inch space. If you can make any use of it, you are welcome. I have not a patent on it. I thought it might interest you. I also have a tin pulley on a line shaft, — 10-inch diameter, 6-inch face, — which drives a gear-cutter. This is lighter still. I have had it use for some years, and it seems as good as ever.

The PRESIDENT. Is there any other gentleman who would like to ask Mr. Brown any questions with respect to wooden pulleys?

A MEMBER. What is the comparative cost of wooden and iron pulleys of the same size?

Mr. BROWN. These pulleys can be sold cheaper than iron pulleys; approximately the same price for the same size: and it must be remembered that all our pulleys are split pulleys. As regards weight, if anybody wishes to know, a pulley 24×6

weighs 27 pounds; 30×6, weighs 33 pounds. We can give you other sizes if you wish. I think I made a fair statement when I said that the wooden pulleys are from 50 to 70 per cent lighter than any iron pulley in the market.

The PRESIDENT. Mr. Atkinson proposes to give us a new sensation; a new view of an old subject. He proposes to show exactly what proportion capital and labor get out of the cotton industries of this country; and he has a very *graphic* way of putting it before you, which he is about to display.

PROFIT MARGIN.

By EDWARD ATKINSON, Boston, Mass.

[Mr. Atkinson stated that, having prepared an address to be delivered to the Central Labor Lyceum on their invitation, which contained an analysis of the division of the proceeds of the product of a cotton-mill between those who do the work and those who own the mills, it had been suggested to him by the President that it would be interesting to the Association to have this analysis submitted to them. He then suggested to the reporters that, as the subject had been very carefully prepared by him in writing, it would perhaps be better to make the report to the Association from the text of his address to the Labor Lyceum rather than to attempt to follow what he might say to the Association; feeling assured that perhaps the only part of the Address which would be interesting to the Association would be the analysis of the cost, production, and division of the product of a cotton-factory of the most modern description which had been computed by himself with the assistance of Mr. C. J. Goodwin; but of which mill no exact counterpart might be in existence. Having, however, made up the figures, according to the estimate of what they might be under these conditions, he reached the conclusion that the selling price of the fabric in the market would be on that day six and one-fourth cents; after completing the figures he went to one of the large shops, selected a fabric corresponding to the one assumed as a standard, and on asking the price, it was given to him as six and one-fourth cents. Mr. Atkinson has since furnished a complete copy of the address, and it has been concluded to publish the whole of it in the Report to the Association rather than to make extracts from it.]

Ladies, Gentlemen and Fellow-workmen:—

I am very glad to meet you on the evening of a day which is, or ought to be, to all of us, whatever our faith may be, a day of rest and of re-creation. It is my purpose to show you how the great forces — the higher laws which govern the relations of men, to which all the statutes or laws of the State, and all the rules or by-laws of your labor associations, must of necessity be adjusted if they are to have any duration — are steadily, surely, and slowly working to the benefit of the great mass of the people who do the actual work of life either with their heads, or with their heads and their hands combined; or however they get their living, slowly but surely securing to them in this free country, whatever the case may be in others, a constantly larger and increasing share of a larger and larger annual product.

Even to those who make the Sunday more of a holiday than a holy day, I may give a text to this sermon on labor: Do justly. Love mercy. Walk humbly. These are the laws of humanity, however they originated. There are none who need to think of them more than some of you who try to prevent other men from getting their living in their own way, who would deprive them of their liberty of action, and who put a bad name upon them if they don't do what you undertake to tell them to do.

To such as these, I commend the middle part of my text — love mercy. I commend the whole text to those who say that life is a contest between labor and capital.

Look at the picture upon the wall, in which you see so much deep red. It looks like the flag of the Commune. It is the flag of a kind of communism which is justified by science. It indicates the results which come from the peacful development of order and industry, or which will grow out of a true regard to the harmony of interest between capital and labor. These lines in different colors carry with them the promise of a time, not now very distant, when a good living will be so sure to him or her who has fair ability, good health, and a true character, with moderate aptitude for the work which is always waiting to be done — I say it gives the promise of a time when it may

not pay to be rich, if one is content with common comfort and common welfare. I shall try to give you a study of life and work in a few plain, short words.

I must tell you who I am, before I begin my talk. I am not a Knight of Labor, but a Squire of Work; and if I am not wrong, the Squires will get ahead of the Knights in the long run.

Not long since, Mr. Chase spoke to you upon the subject of making a day's work eight hours. He said he would like to debate this question with Mayor O'Brien or with me; and for that reason I am here to speak to you. I shall speak on a broader question than that of eight hours, for that is only a small part of the whole subject which is before you.

A great many of you work too hard and too long. No one can deny that. You don't get as good a living as you might have. There is no doubt about that. You don't want to work more than eight hours a day if you can help it. Neither do I. I don't work more than eight hours a day in order to get a living, and you do. Why should you not control your own time as well as I? You can if you choose to.

The only thing that all men enjoy alike, the only element of life which is common to every man, woman, and child, and which all share, and share alike, is time. Why should I be able to get my living in eight hours a day or less, while most of you work ten hours, some of you twelve, and nearly all of your wives fourteen hours a day? I suppose some one will say that I am a capitalist and that you are workmen; but that is not the whole of it. I am not a capitalist in the sense of being a rich man. To be sure, I have saved some capital, and I am very glad of it; but I don't live on the income of my capital. I save that, and add it to what I had before. I live on my work. Why should I get more for my work than you do? I work with my head only, and you work with your hands. Some of you work with your heads as well as your hands, and some of you don't use your hands at all; you stand by and watch a machine, and your work only is to see that the machine does its work well.

Now, in what do we differ? I sell my work for what some

other men are willing to pay for it. If they don't pay me as much as I think my work is worth, then I say, "Good-by, I will do something else; I won't work for you any longer." You sell your time to another man, and he pays you what your work is worth to him; and if you think it is worth more, you can say "Good-by" to him as he can to you; and you can do something else if you know how, and have saved some capital to tide over with while you are out of work. Perhaps he would be very glad to pay you more for your work if he could. Why can't he? Because the people who buy the goods you make and which he sells will not pay any higher price for them. It is the price of the product that fixes the rate both of wages and profits. Who are the people who buy the goods at the low price which only gives you small wages? Well nine-tenths of them are working people just like yourselves. When you put up the price of what other workmen buy, and do not put up the price of what they make, then you tax them to get a better living yourselves. Is that fair? It is just so about eight hours. If you cut down the work in factories, in workshops and in the building trades to eight hours, you cut down the product; then there will be fewer goods, fewer stoves, fewer tools, fewer houses, and that means a higher price and a higher rent; because, if you count all the mechanics and all who work in the factories whose time can be shortened by rule, there are only about two hundred in each thousand of those who work. Who are the rest? Why, the farmers, the railroad men, the shopkeepers and their clerks, and also the wives of all the mechanics, who have never been counted. Can you reach them by any eight-hour law? Who proposes an eight-hour law for women in the work of their own households?

Is it a fair deal, when you make a law of the State, or a by-law of the trades-union, or in any other way, that makes the many work harder in order that the few may work less? That is not what you mean; but that is what you do, or would do if you could. You say there is enough product made now in eight hours to give every one a good living, if it were only divided on the square. Some of you say that if you could get hold of

what capitalists take out of the product, and divide it among workmen, eight hours' work or less would give you just as good a living, or a better one than you get now.

Well, that is a question of fact. It either is so, or it isn't. I say it isn't, and I am going to prove it.

I tell you the waste by capitalists is nothing compared to the waste by workmen; and so far as I can see, there is no way in which to shorten the hours of labor except to do more or to make more in less time; because labor now consumes so nearly the whole of what there is, that, if all the waste of rich men or by rich men were taken from them and divided among the workmen, it would not make a difference of fifteen minutes a day. If it were divided in money, it would not give the whole body of the workmen the price of an extra glass of beer a day. If it were not divided even, then the deal would be no more fair than it is now — would it? Lastly, if by taking away the profits from capital you lost the service of rich men, you would be compelled to work a great deal harder and a great deal longer than you do now, in order to get as much.

I tell you, my friends, when you are talking about the wages due to laborers, you had better measure the wages due to capitalists, to inventors, to men of science, to men who work with their heads. It is to them that you owe the fact that you can now get twice as much out of ten hours' work as men and women could get fifty years ago out of twelve, thirteen, fourteen. Labor without capital counts one in production, and *with* capital it sometimes counts one hundred. Can the one hundred manage the capital as well as the one? No. If they could, you would all work on the co-operative plan. The reason you do not co-operate now is, that you cannot in that way get as much out of your work as you do now out of your wages.

All this talk about wage slavery is nonsense. There is no slave labor, no compulsion in this country now, unless it is the compulsion of the Knights of Labor; and that is pretty much played out already.

You see I talk plainly; that's what you want, isn't it?

You want facts, and I am going to give them to you. Some

of my friends began to chaff me the other day when they heard I was coming here to speak, and one said I wouldn't dare tell you the truth. I said I would. I told that man he was a condemned fool if he hadn't sense enough to see that what workmen want, more than any other class of men, is solid truth and hard facts, no matter where they hit. Isn't that so? If not, I had better go home.

Now, I am not a big capitalist; but let us suppose that I were one. Suppose I did own a big cotton-mill that would cost a million dollars. Suppose I owned the whole of it, and suppose you were cotton-mill hands; let's start square on that. I wish I did own such a cotton-mill. I would run it just as the mills are run to-day by other people, and will soon show you how much better that way is than any other way that we we have yet found out. We may find a better way, but we haven't yet. I want to start square, just as I did down in the Senate chamber of Georgia a few years ago. I was asked to speak to the Governor of the State and other officers; to some members of the Senate of Georgia; to the United States Senators, and some men who had been, including ex-Senator Toombs, who wanted to call the roll of his slaves on Bunker Hill, but who never found out the way to do it. There were about sixty men in the room, and I told them that I wanted to start square with them. I said, "I am an old-time Abolitionist; I was a Fre-Soiler; I helped to fit out John Brown with Sharp's rifles for Kansas, and now I am a Democrat." I said; "No man has a right to call himself a Democrat who is not willing to give every other man an even chance to get a living, and to vote without any distinction of race, color, or station in life. Now," said I, "if I speak, this is my platform. Do you want to hear me? If you don't, say so now." Well, they did want to hear me; and I gave them some hard facts, which have not been without good results, either in Georgia or in other parts of the South.

I want to be just as square with you; and although I am not a big capitalist, I am a capitalist compared to some of you. I dare say I earn ten times as much in a year by *my*

work as most of the men in this room, and I don't work over eight hours a day to get a living. When I work over eight hours a day, I work for the fun of it—studying labor problems, making speeches on the eight-hour craze, trying to find out what the Knights of Labor really mean, and all such questions.

I will go one step farther. There is not a man or woman in this room who does not pay me something every year. Now, if you want to know why you pay me, and how you pay me, and what I do for you, and how I earn it, I will go on with my speech. If you don't want to hear it, I won't.

You observe that I must use the personal pronoun "I." It is you and I who have got to talk this out, and not somebody else. I can earn enough for all my wants in less than eight hours a day, and some of you cannot. Why not? Is it my fault or my neighbor's fault that you don't get enough to live in comfort without working more than we do? Are you poor because some other fellow is rich? I say "No"; but some of you say "Yes"; now who is right? Before I get through, maybe I can prove, even to you, that you had better pay me twice as much as you do rather than not pay me at all.

My regular work is to stop the cotton and woollen mills from being burned up, in which the cotton and woollen goods of which your clothes are made were spun and woven. The more mills we save from fire, the more goods you have, and the lower price you pay for them. I am paid for that, and my men are paid for that; and a part of what we cost goes into every yard of cotton and woollen cloth that you wear. The rent of the office which I use, and the rent of the land on which the building stands, is charged to the cost of the cloth; and before you can buy the cloth, you pay your share of that rent. The land is worth twenty dollars or thirty dollars a foot. Suppose all the taxes were put on the land, then the tax would go into the rent, and the rent would go into the cost of the cloth, and you would pay it. Watch the taxes; don't pay too much.

Now, I claim for every cent you pay me, I save you ten. I say that for every cent that almost every great capitalist receives,

workmen are saved ten cents, more or less, somehow or other. I will except the capitalists who make rum. If you will have the rum, they will make it for you, and you will waste your money on it. That is your lookout and theirs. I don't make rum, and I don't sell it. I say that every capitalist who puts his money into useful work, into cloth, food, fuel, metals, and the like, saves every workman a great deal more than he takes from him. The poor are not poor because the rich are rich. The poor are not poor because capital takes a bigger share than it ought. The poor are a great deal less poor and a great deal less numerous than they would be except for the service of capital, of which they enjoy the greater part of the benefit. The poor are not poor because they have no land. Land won't save a man who doesn't know how to use it. There are 300,000 Indians in this country, about as many as there ever were. They used to own all the land, and they still own 150,000,000 acres of it. It is kept for them by the Government the United States. The Indians enjoy the ownership of land for the benefit of all the Indians who occupy it in common, and who are not even taxed on it. It comes to five hundred acres apiece for every Indian, every squaw, and every papoose; how much good does it do them?

There is plenty of land down South, good land, to be had at twenty-five cents to two dollars an acre; I own a thousand acres of it myself. I wish I didn't. I made a very poor bargain when I bought it for two dollars an acre. You can go and buy it. Why do you work for wages here if you don't want to? Why do you work more than eight hours a day if you don't want to? Why do you buy the cloth which you have on your backs, and pay me something on every yard, if you don't want to? Nobody can compel you to work for wages. Nobody can compel you to work more than eight hours a day. Nobody can compel you to buy factory cloth if you don't choose to. I can't compel you to pay me a cent if you don't want to. Nobody can compel you to pay rent for a workshop or a dwelling-house if you don't choose to. You can buy land even in Massachusetts for less than nothing an acre. What I mean is, that you

can buy good houses and barns and good farms for less than the cost of the houses and the barns, with the land thrown in for nothing. Why don't you? Because you have no capital, not because I have the capital. It is not because some other man has saved a part of his work that you have none; that isn't the reason. It is because you have not saved a part of your work, or else because you could not get as good a living on this land as you do now, if you owned it. You answer me that you live in the city, and pay rent, and work for wages, in order to live here; and you work ten or twelve hours a day for wages here in order to live here at all. Very well. Isn't it better to work ten or even twelve hours a day rather than not to live at all? Of course it is; or else you'd quit if you dared to, and go somewhere else. There is plenty of room in this world and in this country. There is a great piece of the South that I have spoken of, the middle mountain section, bigger than Great Britain and Ireland together; it has a better climate than Boston, better soil than Massachusetts, plenty of trees, plenty of water, iron, coal, copper, lead, all sorts of things. If you went there you'd have to work for yourselves; you couldn't help it; you couldn't work for wages because there isn't much capital, and there would be no capitalists to hire you. There are 2,000,000 or 3,000,000 people down there who work for themselves; they spin their own yarn, they weave their own clothes, they cut their own wood, they make their own furniture, they hoe their own corn, they distil their own whiskey (moonshine kind), they build their own houses out of logs, they are free to do just as they like, and they work a great deal harder than you do; and they have hardly enough to eat, drink, and wear, because there is little or no capital there to help them.

Now let us go back and find out who was the first capitalist and what he did. We know something about the men who lived before there was any written history, because they left their tools. Here are some of them. This is a stone axe. It was found under thirty feet of gravel down in Delaware. It may be twelve thousand years old, it may be one hundred thousand years old. It was used by men who lived in the stone age,

before the use of metals was known to any man. They made their axes of stone. Here are some better ones. They made their arrow-heads of flint; here are some. They made bows, and strung them with gut. They hunted; they fished; they ate clams; they have left piles of clam-shells all along the coast from Florida to Maine, where they came down from the woods in summer and had a good time; and in the big heaps of clam-shells you will find lots of arrow-heads and some of these axes. This axe is the oldest kind of capital. Now, can't you imagine the man who first found out how to chip off a bit of rough stone and make an edge to it, and who then stuck it into the fork of a split stick, and bound it with a piece of gut? Next he chipped off a flint arrow-head, and bound it to an arrow to shoot with. The other fellows couldn't do it. He began to hunt, and he killed a great many more beasts than the other fellows; he had more meat than he could eat; he had more skins than he could wear. What did he do? He swapped for something else. But what did the other fellows do? Didn't they swap with him for his axes and his arrow-heads? Why, then they had ten times as much to eat and ten times as many skins to wear as they had before, didn't they? Next they must have found that, as long as he could make axes and arrow-heads, and they couldn't, he had better do that job, and let them do the hunting. Then he became the first manufacturer. He spent all his time making axes and arrow-heads. The other fellows brought him all the meat he could eat and all the skins he could wear. They built him a stone house, and they did all they could so as to save his time. Didn't they make him a capitalist? Not because they cared any more about him than they did about the next man, but so that they themselves could have more axes and more arrow-heads with which to get their own living. He was a capitalist, and they were hunters. Were they not all of them better off than any of them had ever been before?

Now, here is a modern axe made down in Douglas or in Hartford. It cost fifty cents. It takes a big capital to make this kind of an axe. It takes a first-class man to look after it. He is worth a high price. Who pays it? You pay it if you use

axes; because, by paying him a high price for the axe he makes by the use of his capital, you have more axes and better axes than you had before. You could not make them yourselves if you tried to. Then, where you pay him one cent, does he not save you ten cents' worth or more of work?

As I said the other day in a meeting of this kind, if you don't want to pay Mr. Vanderbilt for bringing your barrel of flour from Chicago to Boston, you needn't; you can wheel it yourself. I had rather pay Mr. Vanderbilt to carry my trunk or my barrel; he can do it cheaper. Suppose the old man did make $100,000,000 out of the job; he saved me a dollar for every cent that he made out of me; he saved you a dollar for every cent that he got by moving the flour from the great prairies of the West down here for you to eat. How could you do without such men? Wouldn't it then take you and me ten times as long and ten times as hard work to get less than we all get now?

There is one kind of work that I know all about, and that is making cotton goods in a mill. I have been working about cotton-mills in one way or another ever since I was a boy. When I first went into a store in 1842, the men and women who worked in the cotton-mills worked thirteen or fourteen hours a day, and they could not begin to make as much cloth in a day as they do now, while they only earned half as much wages.

The owners took a bigger slice out of every yard for their profit than they do now; but the product was so small, that even the big slice out of each yard did not make them very rich.

It was just the same in every other kind of work then as it was in the cotton-mill, — longer hours, harder work, poorer pay; too long, too hard; but it took all that time and all that labor to raise food enough, or to make cloth enough, or to get fuel enough to go around; where it took thirteen or fourteen hours then, it now takes but ten hours. You older men remember. Am I not giving you facts? By-and-by it will take less. I think it very likely that your children will be able to get just as good a living, and perhaps a better one than you do,

by working eight hours a day; but they won't get it by Acts of the Legislature. If you can pass a law to shorten the general hours of work (and it won't be fair unless you make it general), if you bring every kind of work down to eight hours or less, there will not be houses enough to give you as good rooms as you have now, there won't be clothes enough, and there may not be food enough to go around. You can't work it that way. You want to shorten the hours of work of the city laborers, and you vote that way with the hope, that, after their work is fixed at eight hours a day, you will be better able to get the same time for yourselves. Now if your shorten the hours of work of the city laborers to eight hours it will take more men to do the work, won't it? City work is not machine work; that is, the real work is not. Some of the political work is done by machinery that I should like to smash as well as you. The real work is hand work, most of it. Then if the pay is kept at the same price, it will cost more. Then the taxes will be higher. Who pay the taxes? You do. You can't make the taxes stay where they are put. You may adopt Mr. George's plan of putting all the taxes on land, but you can't make them stay there. Nobody will buy, or hire, or occupy that land to build houses or shops on unless they can charge the taxes to the tenant or occupant, or put the taxes into the price of the goods that are made in the factory or sold in the shop. If they couldn't collect the taxes put upon them, then they wouldn't get any profit on their capital invested in the houses or in the buildings; and, if there is no profit to be had in building houses, or shops, or works, or factories, who but a fool would build them? Would you?

If you choose to vote for men who will shorten the hours of city laborers to eight hours a day, you have a perfect right to do so, because you will pay most of the bill. Working people number ninety out of every one hundred at least. I mean working people in the way in which you use these words; people who work for wages or small salaries, and are employed by others and not by themselves. In the cities, especially, they number nine out of every ten or more; and the consumers,

most of whom are working people, pay all the taxes at the last end, no matter where they are first put. That is what I think is the fact.

I have said that I know something about making cotton goods. Now I am going to show you what I know. I will try to show you what share the mill-owner gets out of the cotton cloth, what share the managers get, and what share the workingmen and women get.

There have been more laws passed to regulate the hours and conditions of the work in the cotton and woollen mills of Massachusetts than have been passed in connection with any other set of working people, and more of the same kind are called for. If you had the power, you people here, you would not let the owner of a cotton-factory run the machinery more than eight hours a day if you could help it; and I will show you what would happen if you had your own way. You would have to wear your old shirts a great deal longer or go without any, because at least nine-tenths of the cotton cloth made in the mills is worn by working people.

Before either you or I can judge whether the present division between labor and capital is right and just or not, I think we ought to know just what the division is. Isn't it so? You think capital gets too big a share. I don't. I think capital serves you and helps you and gives you a better living than you could get in any other way, and I think capital now serves you at a low price. I think you cannot afford to employ capital at much less price than you now pay for it; because if you succeeded capital would go somewhere else, and you would get left. Then what are you going to do? A hundred years ago, as nearly as I can make it out, it took more time and more hard work for a family to get their clothing than it did to get their food. Even fifty years ago it took a good deal more time to get clothing than it did to get food. Now it takes a great deal less time to earn money enough to buy clothing than it does to buy food. Where a man spends a hundred dollars a year for meat, flour, butter, cheese, potatoes, etc., uncooked, for his own use, he need not and does not commonly spend more than

forty dollars a year for his clothing, ready-made, including his boots and hats.

Nothing has become so cheap as cotton cloth. There is no art in which the share of labor and capital can be set off, one against the other, so easily as in this art. The accounts have been kept in such a way for fifty years as to make it very easy to show how much the labor costs and how much the capital costs in a piece of cotton cloth.

Here is a good, solid sheeting or shirting, which I bought yesterday at one of the big shops for six and a quarter cents a yard. The average use of cotton cloth would be forty yards apiece every year if it was all of this kind, but the kind varies. The real average is fifty yards; some of it narrower and finer and lighter, and some of it coarser. Now, cotton goods are used more by the million, by the working people, than they are by rich people. You can buy a year's supply, forty yards of this cloth, for two dollars and a half; or for two days' work of a common laborer, at a dollar and a quarter per day. How much profit to the rich man who owns the mill do you suppose there is to-day in that cotton cloth? It is just one-third of a cent a yard out of the six and a quarter cents that you pay for it. That is the profit of the mill. The rest all goes to the working people in one way or another. This I am going to prove if you don't believe it; and after that I will prove to you that working people get the biggest part of the owner's profit.

When you buy forty yards of cotton cloth at two dollars and a half, you pay the owner of the mill fifteen cents profit, but you also pay about fifteen cents more to other people for profit; that is thirty cents profit in all; and you pay two dollars and twenty cents directly for labor.

In a lecture of an hour I cannot show you how I prove every part of what I am going to say; but I have been in the business more than forty years, and what I tell you is either true or it is not; you can take it or leave it; you can believe me or not, just as you please.

Now, look at this chart. I call it a labor spectrum. Do you know what a spectrum is? It is not a ghost, it is a fact.

Somebody found out a few years ago that, when you look at the light of the sun through a set of prisms or pieces of glass fixed in a certain way, you divide up the light of the sun into different colors and separate lines; and each color or each line proves that there is some one kind of gas burning about the sun. Each line means a different gas. It is very hot up there; iron is reduced to gas; soda is reduced to gas, etc. All these hot gases show different lines and different colors in the spectrum, so that you can really tell what's going on about the sun. This instrument, which they call a spectroscope, has been applied to a great many uses. In making steel they use it; they can tell when some things that would hurt the steel if they were left in it are all burned out and gone; and that's one way in which science has helped you to get cheap steel for your tools. This method is called a spectrum analysis.

Now, I have taken this piece of cloth and have made a spectrum analysis of it. I am going to show you how much of it is cotton, how much of it is labor in the mill, how much of it is the salary of the treasurer and of the agent, how much of it is profit, who gets it, what it costs you to employ a capitalist to make your cotton cloth for you instead of making it yourselves, if you knew how. You must have cotton and woolen cloth; you must either make the cloth yourselves, or hire somebody else to do it. You buy it because you can get forty yards for two days' work of a common laborer. How much work do you suppose it would take to make that forty yards yourselves by hand-cards and spinning-wheels, and hand-looms, as they do down South and up in Canada to-day because they don't know any better?

Five men and women — two carding, two spinning, and one weaving — can in one day make eight yards of cloth a great deal coarser than this; this is equal to one person's work for five days; forty yards would take five times as much, or twenty-five days; and when you had the cloth you wouldn't wear it any more than you would wear a crash towel if you could get any thing else, because it would be so coarse and so rough; therefore you pay a capitalist fifteen cents profit on

forty yards of cloth, in order to save yourselves twenty-three days' work (mighty hard work at that) in getting good, smooth, soft factory cloth, instead of coarse, wiry, rough homespun. Who gets the best of that bargain? If your work is now worth a dollar and a half a day, and you save twenty-three days, I make it out that the capitalist who owns the mill saves you thirty-four dollars and fifty cents, and charges you fifteen cents for doing it. But perhaps you say that even in this case the rich man who owns the mill gets too much; and the carder, the spinner, the weaver, and the other hands who do the work in the mill get too little. Well, we'll see about that. We want the facts first, then we'll know who gets too much and who gets too little if the divide isn't a fair one.

Now, look again at this chart. You may suppose that I and my brothers own a cotton-mill which would cost to-day a million dollars to build. We don't, but I wish we did. I hope my boys will. I am bringing some of them up to this trade, and you can bring your boys up to this trade if you want to: perhaps your boys will get ahead of my boys. There might be three of us. I know just such mills where two or three men do own a mill worth a million dollars. Now, let us see what they do with it. They would employ 950 hands in the mill, or a little over $1,000 capital to each hand; they would buy 10,000 or 12,000 bales of cotton every year, and they would make that cotton into 17,500,000 yards of cotton cloth just like this. This would give 437,500 men, women, and children forty yards apiece per year. At six and a quarter cents per yard, this comes to $2.50 cost to each person, or $1,100,000 in all.

Now look at this top square, No. 1, in light blue color.

[The so-called spectrum analysis of a piece of cotton cloth was shown on a large chart, on which each part of the cost was colored separately, so that the exact proportion was made very clear.

In order to give the same facts so as to be made clear to the eye, the accompanying table has been prepared in the speaker's usual method of lines of different length.]

This square, No. 1, represents the cost of the cotton in the

Capital $1,000,000 in a Cotton-Mill Making Medium Sheeting 36 Inches Wide. Product per Year 17,500,000 Yards, at about 6¼ Cents. Value, $1,100,000.

		Per Yard.
1. Cotton at 10c.	$575,000	3.267 cents.
2. Mill labor	285,000	1.6194 "
3. Supplies	55,000	.3125 "
4. Depreciation, 4 per cent.	40,000	.2269 "
5. Insurance and general expenses	10,000	.0569 "
6. Taxes	15,000	.0850 "
7. Freight	10,000	.0569 "
8. Treasurer, agents, and clerks	20,000	.1137 "
9. Commissions and guaranty	30,000	.1706 "
10. Profit, 6 per cent.	60,000	.3412 "
Cash	$1,100,000	6¼ "

Computed Profit on all Parts of the Work.

Cotton, 5 per cent.	$28,500
Presses and transportation	18,000
Supplies	5,500
Depreciation, new machinery	5,000
Insurance and general expenses	1,000
Freight goods	4,000
Salesmen	1,000
Merchants	11,000
Treasurer and agents' salaries	11,000
Owners, 6 per cent.	60,000
Total	$145,000
Taxes	15,000
Labor all	940,000
Total	$1,100,000

By the use of the combined capital on the farm, the railroad, and the factory, on which these profits may be earned, one producer has been enabled to furnish 129 consumers with 40 yards each of medium cotton sheeting, 36 inches wide, in each year, at the present price of 6¼ cents per yard, or $2.50 each person.

If the 950 mill operatives be considered as a separate force, one hand provides 460 consumers with 40 yards each per year.

It would require 95,000 hands operating spinning-wheels and hand-looms to make the same quantity of 32-inch coarse Osnaburgs, such as are still made by hand in remote sections of the South.

Labor on cotton, supplies, railroads, repairs, and on distribution of goods .	$940,000
3,400 persons.	

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		Per Yard.
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2. Mill labor	285,000	1.6194 "
3. Supplies	55,000	.3125 "
4. Depreciation, 4 per cent.	40,000	.2269 "
5. Insurance and general expenses	10,000	.0569 "
6. Taxes	15,000	.0850 "
7. Freight	10,000	.0569 "
8. Treasurer, agents, and clerks	20,000	.1137 "
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ALL PROFITS BROUGHT FORWARD, $145,000.

Spent by those owners on absolutely luxurious consumption	$22,000
Spent by all who share in all profits or salaries for the support of their families, among about 170 persons at $400 average each.	68,000
Added to capital by the construction of new works, divided among 100 mechanics and other workmen, at $550 each,	55,000
Total	$145,000
Computed saving of 3,400 working people at 5 cents a day each, 300 days per year,	49,650

FINAL DISTRIBUTION OF $1,100,000 PRODUCT.

Consumed by owners, 2 per cent. . . .	$22,000
Consumed by laborers, 87 12-100 per cent.	958,650
Saved by capitalists, 5 per cent.	55,000
Saved by laborers, 4½ per cent.	49,650
Taxes, 1 38-100	15,000
Total	$1,100,000

A CHART BY LINES.

Compiled by EDWARD ATKINSON, Boston.
April, 1887.

cloth, — $575,000. It would take about 30 planters, 400 small farmers, and 1,500 field-hands to raise this cotton; also about 180 men employed in the presses, baling, packing, shipping, marking, including a lot of men on the railroads, who get the cotton from the farm or the plantation from down South up to the mill in the North.

The next square in red, No. 2, is the proportion of labor in the mill, — 950 pickers, carders, spinners, and weavers, overseers, and second hands; I don't count in the agent, nor the paymaster, nor the clerks; the 950 men, women, and children now earn on the average $300 apiece each year, in ten hours' work a day, — $285,000. Forty years ago they worked thirteen hours a day, or even more, and earned $175 apiece. Just think of it. A few days ago Mr. Henry N. Slater, the son of Samuel Slater, the man who first brought the art of cotton-spinning to this country in his head, because no plans on paper could be safely taken away from England, was in my office. He is over eighty, but his mind is as clear and as bright as ever; and he told me how he worked in those first mills, not only thirteen, but fourteen, and, in the long days, fifteen hours a day.

How is it now? Every operative can buy more clothing, more food, and better shelter with each dollar of the $300 now earned in ten hours' work than they could with each dollar of the $175 forty years ago, earned in thirteen or fourteen hours' work; so you see, even if they are not very well off now, they are yet a great deal better off, and have easier work and shorter time now than they did then.

Next you see a narrow line, brown, No. 3. This represents the proportion of the cost of the fuel, the oil, and the starch, and the materials used to keep the machines in good order; and it represents the work of about a hundred men outside the mill, — $55,000.

The next line, in yellow, No.4, represents the depreciation of the mill. You may try to keep a mill in good repair as well as you can, and charge all the cost of the repairs to the cost of the cloth, and still the mill will grow no better every day, because men keep inventing better machinery, that does more work at

cost and higher wages; and unless the owner keeps up, and rs for the depreciation, he will fail sooner or later. I have in four per cent for depreciation, and that means the work eighty men making new machinery all the time, for $40,000. The next black line, No. 5, stands for the taxes, — $15,000 a ar.

The next little narrow line, in pink, No. 6, stands for the in-ance and the general expenses, — $10,000. This is where I ne in. You help to pay my salary, because my salary goes o the cost of every yard of cotton cloth you have on your ks. It is all on this pink line, but you can't see it.

The next line, in green, No. 7, is what is paid to the railroads o take the goods to market, — about $10,000.

The next line, in red, No. 8, is what is paid to the treasurer, agent, the superintendent, the paymaster, and all the clerks. ave put it in red, because it represents labor as much as the rk in the mill; mighty hard work, too. I know what it is, ause I have been there. It comes to about $20,000 on such ill.

The next line, in violet, No. 9, is the cost of selling the goods wholesale, the commission paid to the merchant, the salaries his salesmen, the wages of his porters, his draymen, and all e men who work in the shop; — about $30,000 in all.

And this last line, in dark blue, No. 10, is six per cent profit, $60,000. If you buy forty yards apiece every year of this th, at the present price of six and a quarter cents, and if I rned this mill to-day, all that I could make out of you would six per cent profit, and four per cent depreciation, with tton at ten cents a pound. Each of you would, therefore, pay e fifteen cents a year. Now, if you can do better, why should u buy my cloth? Why don't you make it? If I owned that ill, should I be a cheap man for you to employ, or not? That's hat I want to know. I have given you the number of men, omen, and children who would be required to raise the cotton, send it to the mill, to make it into cloth enough to give over 0,000 other men and women forty yards a year each. I have own you what they earn and what you pay, by the colors on

this chart. Here are the proportions, shown by lines of different lengths in my usual way.

But that is not the end of it. You will say that the cotton planter makes a profit. So he does, a little. You will say that the railroads make a profit. So they do, mighty little. You will say that the men who make the starch, the oil, and the fuel, make a profit. So they do. But I can show you just about how much each of them makes, when trade is as good as it is now.

If you put in the profit on the cotton, on the presses, on the railroads, on the starch, and the oil, and every thing else all together, it comes to about $63,000; add the profit of the mill, $60,000; then put in the treasurer's salary, the agent's salary, and what the two merchants get out of their work after paying all their clerks and salesmen, — call that all profit, — $22,000 more; and then the whole profit on the whole business comes to $145,000. All the rest is labor and taxes. Here it is, right here; this big red square shows what the working people get, 3,400 of them, on all the work, — $940,000. The blue square is all the profit, $145,000; and the little black line is the tax, $15,000; and that uses up $1,100,000.

Take it by the yard. The whole of the labor in a yard of this cloth is five and thirty-three one-hundredths cents. The whole of the profit is eighty-four one-hundredths of a cent. The whole of the tax is eight one-hundredths of a cent. You each use forty yards apiece a year, you workmen; you pay to other workmen every year for your forty yards two dollars and thirteen cents; you pay to the planters, to the railroad men, to the mill-owners, to the merchant, to the agent, and the treasurer, thirty-four cents a year; and you pay to the tax of the town in which the mill is situated three cents a year. Can you do any better? "Yes," you say, "we want to own the mill itself." Well, why don't you own it? You can save money, — some of you do; you can buy shares in just such a mill if you want to, or you can get up a co-operative mill if you want to, but I should advise you not to do it; it is risky business. I think the Lowell factory-operatives who put their money into the old Lowell Savings Bank for the last

thirty years are better off to-day than if their money had been put into almost any of the Lowell cotton-mills.

But we haven't come to the end of it yet. There is a little more labor when the profits, $145,000, are divided. Now look at this little square, which is just the same size as the other square, or profits, up above. It is divided up. The three mill-owners get the biggest slice, $60,000, or $20,000 each; three blue squares. The treasurer, agent, and two merchants get the next division, $22,000. The profit on the coal, oil, starch, railroads, and the planter's profit, is divided up into these little squares, 50, 60, or 70 of them, each getting a small slice.

But now what do these people do with all their profit? They can't eat it, or drink it, or wear it, not the whole of it. All any one of them gets in this life is a house or a room to live in, some food to eat, some clothes to wear, some fuel to burn, and something to drink. I should like to see any one of you get more than that. That is all that I can get out of it; and what I eat and drink and wear is what I cost; isn't it? I may spend a great deal more than I cost; but what I spend supports some one else, does it not? What I cost myself, is what I consume.

Now, let's see what becomes of the profits. Here are the three mill-owners, of whom I wish I was one. They have $60,000 a year among them, $20,000 apiece. Suppose they waste a little over one-third of it, $22,000, on fast horses, champagne, fancy farms, and that sort of thing. Some of them do. This little black square represents the waste; and if three of us owned this mill, and wasted this amount of money on ourselves, that is what we should cost; and you would pay it if you could afford to. If you thought you couldn't, you wouldn't. We couldn't make you buy our cloth. All the other men, all of them who earn each a share of this profit, would support their families, and they would spend about as much as this pink square; say $68,000. If we assume that this is paid to servants, tradesmen, teachers, musicians, gardeners, farmers, and the like, at about $400 each, it would be divided among 170 persons, partly or wholly supporting them.

We cannot assume that even capitalists as a rule save and add

to their capital on the whole more than they spend for the support of their families. Of course there are a very few rich men who save more than they spend, but their savings are a very small part of the whole savings of the people. We may assume that the owners of the cotton-mill, and the others who share the other profits, save in each year about five per cent of the of the value of the product to add to the capital in their works or elsewhere. This saving, five per cent of $55,000, is represented by the square in dark red; this being for building a new mill, or new works of some kind, would be paid out for the service of about a hundred carpenters, masons, machinists, each of whom would earn $550 in a year in doing this work. Is that paid for labor or not?

Lastly, workmen who are prudent, judicious, and cautious, save something. We found that there were 3,400 working people engaged in the product of cotton cloth worth $1,100,000. Suppose each one saved only five cents a day for each working day, or the price of a glass of beer, — fifteen dollars a year, — then the aggregate of the saving of all engaged in the work would come to $49,650. This added to the sum saved by capitalists makes 104,650 added to the capital of the country out of the $1,100,000 product. It is represented by the green square. It is a little less than ten per cent of the product, and this result agrees with all the observations that I have been able to make in regard to every art; namely, that not over ten per cent of the entire product of the United States ever has been, or ever can be, saved and set aside to be added to the capital of the country either by the workman, the merchant, the owner, or the capitalist, all combined.

In this last analysis you now have the final division. The little black square at the left, No. 1, represents in its proportion to the rest of the line, the cost of the three rich men who own this mill, even if they waste $22,000 a year in absolutely wasteful expenditure. I use long words for them. It is as much as any three men owning such a mill, and running it themselves, would be likely to waste. In the second part of the line, colored in red, you get the proportion of the product which is con-

sumed by those who do the work, or the cost of what their product is when exchanged for beef, pork, mutton, coal, clothing, boots, hats, dwellings, and other necessaries of life. Their cost is $958,650. The taxes take $15,000 from workmen and capitalists.

In the third division, in dark green, you have what is saved by the capitalists, $55,000; and in the fourth division, of light green, you have what was saved by the workmen at five cents a day, $49,650. Or put this division into so much a yard, and you find that in each yard of cotton cloth the capitalist has wasted one-eighth of a cent a yard, the laborer has consumed five cents and a half, and the capitalists and the laborers together have saved five-eighths of a cent a yard, and that is the end of it.

Now, what are you going to do about it? If you still say that the profit of $145,000, of which $60,000 go to the owners of the mill is too much, and if you could in any way reach and divide it among those who do the work in the mill, then what would become of the 270 people among whom these profits were divided by those who spend the profits in supporting their own families, or in building a new mill?

There were 950 operatives in the mill. Suppose you take all the profit, and divide it among these mill-hands; then you say they would spend it in supporting the 270 who now work for the owners of all the capital. But you know very well that what mill-hands spend would go in a very different direction. It might be just as useful, it might be all right. All I have to say is this: When you take away the profits from the owners and managers of the mills, then all the makers of fine cabinet-work, of pianos, of fine paper-hangings, all the carpenters and masons who build the better kind of houses, and all the skilled mechanics, of whom there are probably a good many here, who now work for the owners of the mills, and all the teachers and musicians who are employed by them, would be obliged to find some other kind of work. They must either go upon the farms to make more food, or go into the cotton-mills to make more cloth. There is food enough and cloth enough already; what

should we do with what these men made? In other words, you can't have more than the cat and her skin. Labor now gets the cat, and the owner gets the skin. That's about the end of it.

You must either make more cloth with the same machinery and the same number of workmen, and sell it at the same price and at no lower price, or else you can't get out of the cotton cloth any more than you have put into it. I have shown you exactly how it is divided now. Can you better it?

You may not like the statement. You may feel like using some swear words about me. Well, that won't hurt me; and if it does you any good I hope you will swear, but you don't damn the facts; if they are the facts it won't alter them if you do. If they are not the facts, if I have not told you the truth, then go ahead and find out the truth in your own way. That is what you can do in these organizations, clubs, Knights of Labor, eight-hour associations; and the more you study, the more you find out that the capitalist is your friend and not your enemy. If you treat him right, he will treat you right.

I have taken cotton cloth as an example, and it is the worst example that I could take to prove the service of capital. Why is it the worst example? Because it takes $1,000 to set one man, woman, or child at work in a cotton-factory. In a woollen-factory it takes only $500. In a boot-factory, only $250; and, in order that the woollen-factory may earn four per cent depreciation and six per cent profit on capital, the proportion of product set aside would be only one-half what I have set aside from the cotton-factory; the line would be only one-half as wide as the profit line on this chart. In a boot-factory it would be only a quarter. "But," you say, "the owners of the woollen-factory, boot-factory and machine-shop get more profit than the owner of a cotton-mill." No, they don't in the long run. If there is any kind of safe business that will pay four per cent depreciation and six per cent net profit on the capital, safe and sure, capital will rush into that business, whatever it is.

Now, suppose the profit on cotton goods went up half a cent a yard: suppose you had to pay seven cents instead of six

and a quarter, or a quarter of a cent interest on money borrowed and half a cent extra profit. What would happen then? The working capital — the money borrowed by cotton-mills is usually borrowed of savings banks — and the one-fourth of a cent interest would go to the savings bank, the half cent extra profit would go to the owners of the mill. Do you suppose they could keep along at that rate? The mill would then pay about fifteen per cent a year instead of six per cent to its owners. I have seen such times, and I have taken such dividends myself, but they don't last. The moment such a big profit is to be had in any kind of work, in come some new fellows, who build a new mill right alongside of you; very likely a better one.

They then pay better wages, they hire away your best men and women, and very soon they bring the profit down as low as it was before, and sometimes down to nothing at all for a long period. This is just what has happened in the last three years to ever so many mills that I know all about, in some of which I owned some stock.

Now, fellow-workmen, it has taken a good deal of work for me to be able to tell you all this. I have been at it forty years, and I have worked thirteen hours a day when I was a youngster. In old times when I wanted to save an extra quarter of a dollar to go to the theatre, I made my dinner of bread and milk, and I saved my money in that way. You can do the same thing only you needn't spend it to go to the theatre unless you choose to; though I think it is a pretty good plan to do that now and then. All work and no play doesn't pay for anybody.

The way to shorten your time and work less hours is to do more while you do work, and I don't know of any other way. I never could find one. Do the best you know how. Work by the piece; work by the hour. If you have any snap in you in these times you can save something. You say you can't? Well, I say that the man who says so right here at this time is bound to prove it. Perhaps you haven't said it right out, but you said it to yourself just now: "I can't save any thing out of what I get." I ask you why you can't, if you are a good workman?

I say you can. I ask you how much you spent to-day that you needn't spend on yourself? But we won't go into that, it's too big a subject. I could show you how to save five cents a day easily enough in the average cost of your food so as to have good food which tastes better than what you get now, which will serve you better; but I can't do it here within this hour. Now, I am going to hit you hard. I am going to tell you which man will come in ahead and which man won't among those of you who are here at this time right before me. You know when the British troops occupied Boston in the Revolutionary War, they nicknamed the people "Yankees." They meant it for ridicule, for "sass;" but I don't know any real Yankee who isn't proud of being a Yankee; and I think the Yankees came out ahead; they didn't choose to be ruled by John Bull; they chose to manage their own affairs, and they do; they have done pretty well on that line. They sent the British troops out of Boston Harbor because they wanted to control their own work and their own time; they didn't want any one else to say that they should do this, and that they shouldn't do that. Well, now, some of you are trying to do the same thing that the British troops tried to do; you are trying to rule the workmen. You are trying to tell men how they shall work, when they shall work, where they shall work, and how long they shall work; you call a man a scab who won't submit. Is that fair play? Now, you won't like it when I tell you right here that the "scab" is the man who will come out ahead, and you will get left. But don't mistake me. I wholly approve of the organization of labor. I don't care what you call it, whether trades-union, Knights of Labor, or by any other name; all that I claim is, that you mind your own business. What is needed now is a club of "scabs;" that is, a liberty club, a mind-your-own-business club. If you have Knights of Labor, why not have Squires of Work? I believe in a squire more than I do in a knight. The squires have been licking the knights for the last three hundred years, getting on top, and by and by they will bury them. We have done with kings, with princes, with dukes, and other privileged classes; now what business have the

knights of to-day to take up the privileges which the squires took away from the old knights long ago? What were these privileges that the princes, the dukes, and the knights used to claim in old times? Just what the Knights of Labor claim now; the right to tell you or me what we shall do with our time and our brains, and how we shall use our hands. That won't work. The squires won't have it. There are more squires than there are knights, only they don't know it yet. Then I say let the squires organize, support each other, and help each other to find out what their work is really worth. They don't want any master workmen; they don't want any masters of any kind to order them around. They want corporals and sergeants, men of their own kind; non-commissioned officers to keep them in line, and to keep them all up to the best mark. When you organize such a club as this, every member will get higher wages because he will be the best man of his kind; each one will be a man who knows how to make his own bargains and manage his own affairs. There will always be work for him at the highest price because he will be the man who will make goods at the highest wages and at the lowest cost. That's the kind of man that every employer wants to find. I don't care whether the times are hard or easy, good or bad, that kind of man always gets work, and always gets the best pay that the price of the goods which he makes will permit the employer to pay.

It is a great blunder to say that while the rich are growing richer, the poor are growing poorer; it is only the poor who can't work well, or who won't work well, who grow poor while the rich are growing rich in this country. The best times for the manufacturer are the times when he makes the most money; and they are always when the wages are highest and not when they are the lowest, because wage-earners are their principal and most important customers.

Therefore, I tell you, organize, organize, organize; but organize the Squires of Work; call in all the "scabs" to join, and don't refuse any man who works for his living either with his hands or his head, with his own capital, or his own tools, or his own brains, if he is an honest and a true man.

There are two things very much needed in these days: First, for rich men to find out how poor men live; second, for poor men to know how rich men work. This is coming; there has been a great change since I was young; most of the boys with whom I went to rather a poor school were sons of rich men. I tried to make a list of them one day not long ago, but I stopped: it was too sad; half of them had died as fools die, of rum or worse. Half my friends in later years have been men who began at the lowest round of the ladder. The most useful and one of the best friends I ever had, began as a mule-boy in a cotton-mill. My best friend now was for many years a common sailor.

There are not as many drones and dudes now as there used to be. Let them pass, they don't cost much; and they are not of much account any way. I can name to you scores of young men of fortune who are now doing the kind of work that does not pay in money, but does pay in human welfare. You cannot spare them.

When we who are on the down grade of life look back over a single generation, only thirty-five years, what do we see?

Has not this country become one great neighborhood in which all men serve each other? Who made it so? Was it not the inventors, men of science, who worked with their heads, and not so much with their hands? Did they not give the men of capital the power to build the railroads, and to bring the food of the Far West to the door of your dwelling, at a profit on each barrel of flour moved a thousand miles so small that it is now less than what the empty barrel is worth to put our own apples in after you have eaten the flour? Are not the hours of work shorter? Is not the work of life easier? Are not all the conditions of life better now than they were when many of you, and when I myself, began to get our own living by the use of our own hands and our own brains? I could prove all this, but there is not time to-night. If you want me to speak again I will do so.

If we have done so much within the span of one man's working life, what will be done in the working lives of our boys who

are just becoming men? If they work as well as we have, if you leave them free to use their own heads and their own hands, if you do not lead them to hope for rest and leisure unless they have earned it or saved it for themselves, then your dream may be realized; eight hours may be enough, and the time saved and well earned will be well spent. I hope for that time. I can see the promise of it underneath the figures which I have put before you. I can read it between the black lines which I have drawn to prove my case; but I am called a visionary and an optimist. I am glad I am.

Therefore, I say to you, I take no stock in those who will not trust you, and who speak of your unions and your clubs as if you had no right to join them. But, on the other hand, I say to you, do not give away your own case. You have no more right to compel men to join your clubs and obey your rules than I have to compel you to work for me if you do not choose to do so.

If there is one thing meaner than a rich man who does not admit that wealth has duties as well as rights, it is a workman who tries to prevent his neighbor from making his own bargains in his own way; and who, when he fails, as he always will fail, next tries to make him contemptible by nicknaming him a "scab."

Now I will stop. It is your turn now. Who speaks first?

But fellow-workmen, before you begin to fire back at me, let me say a word or two personally. I have told you that you and I must talk this thing out. What I mean is, that every poor man ought to talk this thing out with every rich man, or with every man who is better off than he is himself, in order to get at the true question of rights. If I came here to blarney you with soft words about the rights of labor, if I tried to catch your votes by any of the common stuff that is put into political speeches and political platforms, you would scout me, and would never want to hear me again. I despise this talk about the rights of labor. The poor man has no more rights than the rich man. What you want to think about are about the rights of man, whether he be rich or poor. Now you must not think I

have no sympathy with the poor. I don't know what I should do myself if I were to become poor again. I was poor once. I don't intend to keep my children from being poor by piling up my money for them. Every man should try to keep his children from being poor by putting skill into their heads and hands rather than money into their pockets. I tell you here and now, that by the Acts of the Legislature which you have tried for, and some of which have been passed, and by way of by-laws of your Knights of Labor, your clubs, and your associations, which you have tried to force people to adopt, you are driving capital out of the State of Massachusetts. Up to this time the true men of this country, the free men of this country, the scabs of this country, have managed their own affairs fairly well, without much regard to your meddlesome acts; the result of that has been that the men of special skill, who are at the head of their trades, are a hundred per cent better off to-day than they were twenty years ago and more. That is, they can buy twice as much food, fuel, clothing, and as good a shelter to-day for a year's wages as they could buy twenty years ago with what they then earned. The average carpenter, mason, painter, or other mechanic, who minds his own business, and keeps the control of his own time, can buy nearly twice as much, but not quite. The average factory-operative can buy two-thirds more than he or she could buy twenty years ago with a year's wages, and the common laborer can buy fifty per cent more. But this will not go on if you don't stop. There is no time to prove to you what I say to-night; but if you will go up to the State House and ask the treasurer, you can get the facts, and you can find out for yourselves that you are driving capital out of this State into other States where men are left more free than they now are here to manage their own affairs.

Now, if you think I am cold and hard and without sympathy, I tell you it is better than any sympathy, or any "soft sawder," or any "taffy," to tell you the truth. If you don't believe that what I tell you is true, get at the facts yourselves; and when you prove me to be wrong, I will admit it.

I have said to my friends that I should have fair play and a

fair hearing here to-night. I have. I will not thank you for what was due to yourselves while you listened patiently to hard words, but I do thank you for your courtesy to me.

Mr. George Draper. I have been exceedingly interested in what Mr. Atkinson has said, especially in what he has shown us. I believe it is correct, and I believe it is in line with what the old political economists predicted, as far as that is concerned. I have had occasion to read Adam Smith lately, more or less, and I believe he lays down the same doctrine which Mr. Atkinson says he finds true in regard to this; although I disagree with him very much in some other matters. Now I have this to say in regard to this labor matter: Human nature is pretty much the same, whether you go up high, or down low; perhaps the extremes are more alike. We should try to convince the laborers what they can reasonably expect, it seems to me. But what they want is, that each one of them should be a capitalist, undoubtedly. Those who are governed by moral principles, and those who are willing to live and let live, may look at it differently. But the ambition we have got to meet, in my judgment, is the ambition that showed itself a while ago, where one nation wanted to get every thing. It is not simply what share they can get, but they have got to be taught that they cannot each one of them be capitalists, — that there is not enough to go around. Each one of them looks at Vanderbilt with his $200,000,000, and thinks it would make every one of them rich if it were divided. But the amount of it is, that when you come to think of this question of the wealth of this country, and when you have taken out what you must keep in the shape of tools, in the shape of railroads, wharves, cotton-mills, and tools of every description, things that are simply used as tools, that we do not eat or drink, and divide up all the rest of the capital in this country, the richest country in the world, it will not average $250 apiece for all the inhabitants. Now almost all of them want more than their share. Would they be content with that? What we want to do is to educate the people against this wrong information that they are receiving

from those who tell them that there is this wealth; and they are all the time looking forward as though each one of them might be a millionnaire if it was only fairly divided, and they got what belonged to them. That is what we have got to meet.

Mr. ATKINSON. I will say that is very true. I think I put the average accumulation higher than Mr. Draper puts it; I put it at about $500.

Mr. DRAPER. After deduction?

Mr. ATKINSON. After deduction. I think we have accumulated capital, which may be called capital in the most scientific sense of the word, equal to about $500 per head of our present population: I mean actual capital aside from the valuation of land.

Mr. BIRKENHEAD. May I ask how long that blue line, representing profit, will stay blue?

Mr. ATKINSON. I think it is perfectly safe. I think it will stay blue, at a less and less proportion to product, for a long time. I look upon the whole attempt of the labor reformers and Knights of Labor as utterly futile, as against the nature of things, as a very little eruption, a temporary boil or trouble upon the surface; while the great tide of work, wages, and occupation goes on its way under a higher law which controls both the capitalists and the workmen.

Mr. BIRKENHEAD. The reason I asked that question is this: Suppose you had a check come in to-day, how long would that check last you? How long would it be in your possession? How long would it be before it went into labor again?

Mr. ATKINSON. That I have tried to show in the distribution of profit. A man costs what he consumes. I have allowed for extravagant consumption. Life is but a conversion of forces; and the check is one of the instruments by which we transfer capital into labor, and labor into capital.

Mr. DANIELSON. I do not want to question Mr. Atkinson's figures, but I would like to ask him if he is entirely satisfied that the capital he has assumed there, $1,000,000, is sufficient?

Mr. ATKINSON. It would give you about $14 to the spindle as the cost of a No. 22 mill to-day; such a mill would produce

this product at the high speeds of machinery to-day. I assume that the plant is clear, and that the business is on a cash basis; and I assume that the working capital is borrowed at the savings banks, according to the custom which we are all used to. It seems to me clear that the two elements should be separately treated, that the plant should be treated separately from the working capital.

The PRESIDENT. If no other gentleman present wishes to ask Mr. Atkinson any thing further with respect to his very interesting paper, or to comment upon it in any way, a motion to adjourn is in order.

Mr. KENT. I would move that the Board of Government be authorized to make the usual assessment for the current expense of this year, not exceeding $10.

Carried.

Mr. JOHN OLDFIELD. Mr. President, before the Association adjourns, I would like to cordially invite the gentlemen to come come down to No. 1 Hartford Street to-day, and see the patent bare-spindle mule-cop spinning-frame in actual operation. We want you to give it a fair trial. Machine-makers are also invited, as it is the intention of the company to license American machine-makers to manufacture the frames in this country, wherever the manufacture of them is required; thus giving the cotton-spinner the option of purchasing it here, without going abroad for it, and thus patronize home industry.

Mr. PARKER. I move that the thanks of this Association be tendered to Mr. Henthorn, and others who have presented valuable papers here to-day, and who have done what they could to entertain and instruct us.

Carried.

Mr. WEST. I would like to ask one more question of Mr. Atkinson about these profits. I presume you have estimated upon a mill that could be built at the present time on the most modern plan?

Mr. ATKINSON. Yes, sir.

Mr. WEST. Now, the mills that are in existence and in operation at the present time, are not producing what that mill would produce. Did you take that into consideration?

Mr. ATKINSON. Undoubtedly I took that into consideration; and I took an extreme case, because there is where these pestilent inventors and improvers come in. The old mills will go to the wall by and by, and the new mills will come in, and you cannot help it. That is the load that the capitalist has to carry. Go back, as I have, for forty years, on standard sheeting, and what would an old mill of forty years ago be worth to-day? What would a mill of twenty years ago be worth to-day, unless you have spent fully four per cent a year, over and above all repairs, in keeping it up? I take an example of things as they are now. I could take it according to the condition of things five, ten, fifteen, or twenty-five years ago; then you will have a larger and larger share of profits, on the average, every year as you go back, and a less and less share of labor. I suppose the suggestion of Mr. West means that the average profit is not as large as it was some years ago. That is true. It is not necessary to state it here, because you all know it. For several years many mills have made no profit whatever.

Mr. WEST. It seems to me that this explanation should go with the paper, so that the persons to whom it is addressed would understand what the present mills can do.

Mr. ATKINSON. In each ten years, or thereabout, there is apt to be a great fluctuation, — perhaps two or three years of large profit; then two or three years of no profit; and two, three, or four years of slow recovery from depression. But in each of these periods of ten years, each as far back as 1840, I find that the share of the product which has gone to capital has greatly diminished; while the share falling to labor has greatly increased. This is also the rule in all arts to which machinery or invention can be applied, — lower prices, higher wages, smaller profits.

On motion of Mr. Parker, the Association adjourned.

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N. E. COTTON MANUFACTURERS' ASSOCIATION.

PROCEEDINGS

OF THE

SEMI-ANNUAL MEETING,

HELD AT BOSTON,

October 27, 1887.

BOSTON:
WRIGHT & POTTER PRINTING CO.
18 Post Office Square.
1887.

Lewis Atherton

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CALL FOR MEETING.

BOSTON, Oct. 1, 1887.

DEAR SIR, — The stated Semi-annual Meeting of the Association will be held at the Massachusetts Institute of Technology, Boylston Street, Boston, on Wednesday, Oct. 27, 1887, at ten o'clock A.M.

Topics heretofore discussed will still be in order if called up by any member; and, in addition, the Board have the pleasure to announce that the following gentlemen have accepted their invitation: —

Prof. GEORGE F. SWAIN, of the Massachusetts Institute of Technology will address the Association upon the subject of CEMENTS AND MORTARS.

Mr. GEORGE ASHWORTH, of Manchester, England, will present a paper upon CARDING.

Mr. ASHWORTH will also read a brief paper upon a new DYEING PROCESS.

In accordance with a plan adopted by the Board, which was suggested by the President at the April meeting of the Association, the two last-named papers on the foregoing programme have been printed in advance; and any member desiring to examine either of them, before the meeting, will be supplied with a copy by the Secretary, on application.

By vote of the Board of Government,

AMBROSE EASTMAN,
Secretary.

PROCEEDINGS.

Pursuant to the foregoing notice the stated semi-annual meeting of the Association was held at the Massachusetts Institute of Technology, on Wednesday, October 26, 1887, the President, Mr. J. S. LUDLAM, of Lowell, in the chair.

The meeting was called to order at 10.20 A. M., and the call was read by the Secretary.

The PRESIDENT. The following names have been presented for membership in your Association, and the Board of Government recommend their election: —

R. W. EATON, Montreal, Canada.

WILLIAM J. KENT, New Bedford, Mass.

A. TENNY WHITE, Biddeford, Me.

The question was put on the name of each gentleman nominated, and they were severally elected.

The PRESIDENT. Prof. GEORGE F. SWAIN of the Massachusetts Institute of Technology, who was to have read a paper on the subject of Cements and Mortars, has written a letter saying that he has been unable, on account of his appointment as engineer to the Railroad Commission of this State, and the consequent out-door work he has to do, to prepare his paper; consequently we shall be compelled to dispense with that.

Since we were last gathered together our Association has lost two of its most prominent members, WILLIAM A. BURKE, of Lowell, and GEORGE DRAPER, of Hopedale.

To the older members of the Association there were probably no better known names or faces in the profession than these two. Each had been identified with cotton manufacturing for over fifty years, and each had assisted materially in developing the cotton textile industry in this country.

WILLIAM A. BURKE, of Lowell, was one of the founders of your Association. At the first meeting of the promoters, held April 20, 1865, he was named chairman of the committee that framed your constitution, and reported a plan for organi-

zation at an adjourned meeting on July 19, 1865, which was then adopted. He was elected Vice-President on that date, which office he held until his voluntary resignation of it in April, 1873. He died on the 28th of May, at the ripe age of seventy-six, — sixty years of which had been spent in your ranks as a cotton manufacturer, or as a builder of the machines upon which your work is done.

GEORGE DRAPER, while never connected with the administration of the affairs of your Association, was perhaps even better known to the individual members than Mr. Burke. I think it would be safe to say that no one man in the past thirty years has done more than George Draper to advance our industry. Quick to perceive an improvement in method or machine he pushed its introduction with a persistence and energy, with a facility for illustration and a concise statement of fact, that insured its speedy adoption, and it is certain that the rapid progress of our art during the past thirty years has been not a little due to the push and personal force of George Draper of Hopedale. He died on June 7th, lacking only a few months of three score and ten years.

In these two men our Association has lost two of its most valued members, our profession two of its brightest ornaments, and the State two of its best citizens.

The PRESIDENT. The following letter has been received by the Secretary of the Association : —

OFFICE OF GEORGE DRAPER & SONS,
HOPEDALE, MASS , June 23, 1887.

AMBROSE EASTMAN, Esq.,
Sec'y N. E. Cotton Mfrs. Association, 68 Sears Building, Boston.

DEAR SIR : — I send you by this mail a steel engraving of DAVID WHITMAN, who did so much to organize our New England cotton mills more than a quarter of a century ago, and to whom the cotton manufacturing interests of this country are greatly indebted. Among my father's effects is the steel plate from which this engraving was made, and also some fifteen or twenty copies of it. The heirs would be very glad to present the plate and engravings to the New England Cotton Manufacturers' Association if it would be considered by them as valuable.

Will you please drop me a line on this subject, and oblige you

WM

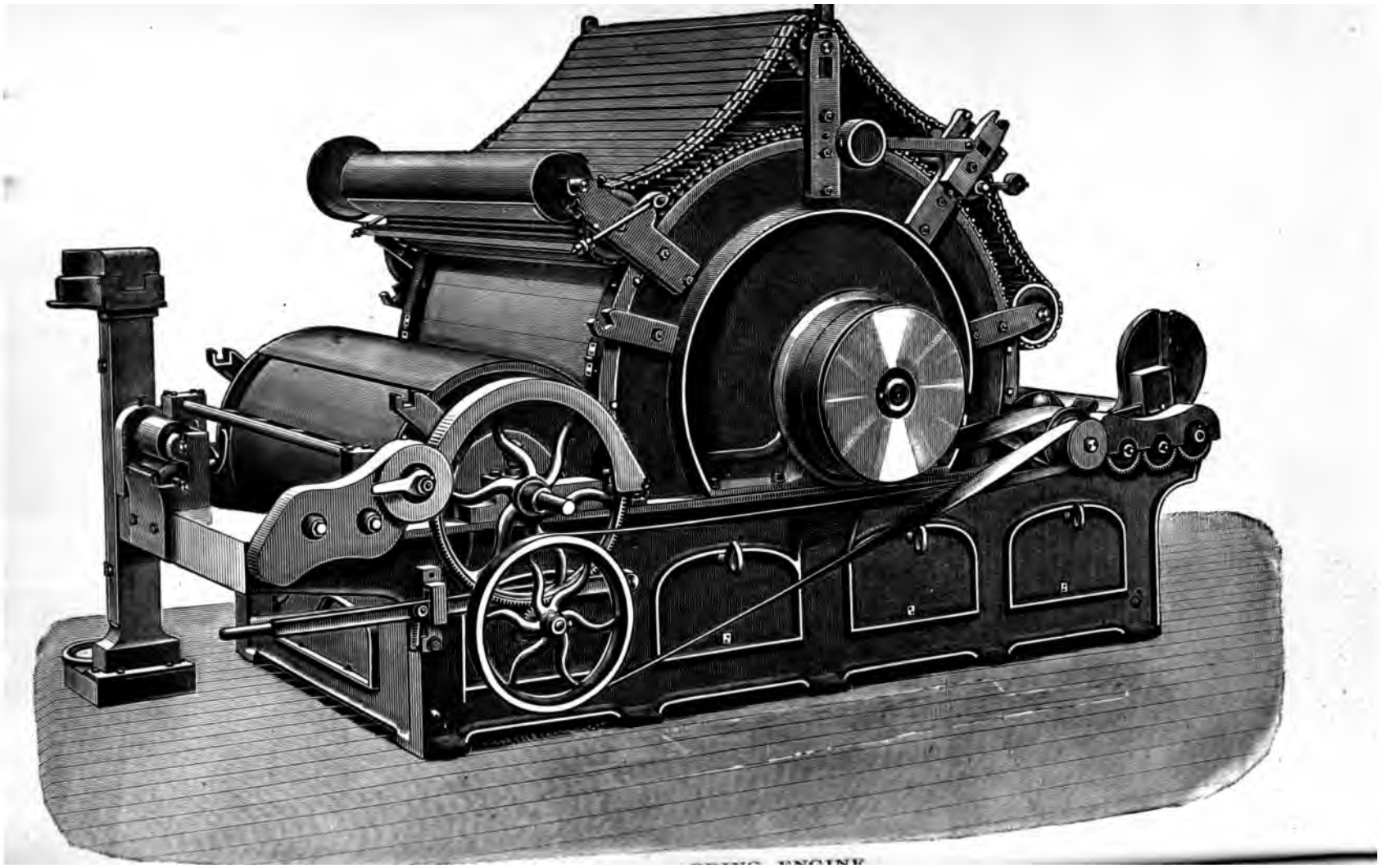
DAVID WHITMAN, as I have no doubt the older members of the Association remember very well, was certainly one of the most prominent men ever connected with our industry. As an organizer, as an arranger of machinery, and for methods of driving it, he was certainly without a parallel in his day. If it is the sense of this meeting that the Association had better accept the offer of the Messrs. DRAPER, and have printed from that plate a portrait of Mr. WHITMAN, which would be distributed with one of the copies of the proceedings of the Association, you will please to manifest it.

Mr. GARSED. I move the acceptance of it, with the thanks of the Association. Carried.

The PRESIDENT. If any member has anything that he would like to bring before the meeting perhaps this would be as good a time as any to introduce it.

No one having anything to bring before the meeting, Mr. ASHWORTH, of Manchester, England, will read a paper upon Carding.

Mr. ASHWORTH. Permit me to say before I begin to read this paper that there are several clerical errors in the printed copies which have been distributed. Owing to the shortness of the time I had to write it the last copy was sent away just in season to catch the mail, before I read it through myself. I have, therefore, made corrections, and if you follow me in the reading you will see where the changes come. There are also missing from the copies a number of small cuts. I have just made rough sketches of them in pencil, showing, as well as I can, what I mean. Later on we will have a full list of sketches to be incorporated in your records. I wish to say that I shall read pretty rapidly through the paper, without making much explanation, or only such as is necessary. At the end, if I think desirable, I will return and go more fully into a description of the sketches and drawings. Then you can have a discussion and thresh it out as you please.



CARDING.

EIGHTEEN YEARS' IMPROVEMENTS IN CARD CLOTHING AND CARDING ENGINES.—THE ASHWORTH CARD AND ITS CAPACITY.

BY GEORGE ASHWORTH.

My appearing at this meeting, and venturing to address you on the important subject of carding and carding engines, has arisen through having read Mr. F. A. Leigh's paper on "English Carding," and the two discussions which succeeded it, as published in the proceedings of the two semi-annual meetings of your association held in October, 1855, and April, 1866. The two pamphlets containing the two reports were put into my hands at the end of last year by an English cotton spinner who had traveled through a great part of your country and visited many of your mills. He called my attention to the paper on "English Carding," and the subsequent discussions, pointing out that several of our improvements had been spoken of very favorably on the whole, but noting at the same time — gathered from his own knowledge and experience of many of our improvements in connection with carding — that several mistakes had been, in his opinion, made, doubtless unintentionally; and he strongly advised me, in our own interest, to write to your president to correct what he thought was erroneous.

I read very carefully the paper on carding, and the discussions which followed, with much interest and pleasure. I only wished that I had been among you with the privilege to speak on the subject to which myself and brother have given so

many years close study and mechanical labor. The reading of these reports decided me to pay the visit to your country which I had for so long a time been desirous to make. It was shown to me very clearly, by what I had read, that the fundamental operation of cotton spinning was exciting the closest attention amongst cotton spinners in this country; and gathering from inquiry, and Mr. Atkinson's remarks in the recent discussions, that I might get permission to address you upon the carding system as developed and introduced by us in England, I came in the spring of this year on business, and to seek the privilege you have, through your president, so readily accorded me.

My original intention was to present the subject before you by an address; later on, your president informed me that the rules of your association required that I should present the subject before you by the reading of a paper, and very kindly offered me some days' extension of time to prepare it. Even then I had but a few days to prepare and send this paper in; and on this account the subject has not been so carefully entered into as it would have been had I had the opportunity which more time would have afforded me. Permit me to say, at this point, gentlemen, plainly, that I am here on business purely; to offer to you as business men our own improvements in carding appliances; in short, to tell our own story. On this account, therefore, let me say, that I don't think you can regard me as an entirely impartial authority, because the ideas I shall present to you are principally our own, and not those of others. Such parts of the art of carding as I shall offer for your consideration, with the scientific basis upon which they are built, are mostly the outcome of our own study and labors upon the question; and the various improvements of the machine and its furnishings are, with one exception, our own, as developed and introduced by us in England during the last eighteen years.

Mr. Leigh, in his paper, gave you, as far as his time and knowledge permitted, a fairly accurate account of most of the improvements of carding appliances used before, and up to that

time, in England. Most of this, though common knowledge amongst English spinners, was no doubt interesting and valuable to you. You will therefore not need that I traverse this ground again; nor would it suit my purpose to do it. The reason is — and I think it is a logical and business-like one — that as business men you wish to-day to hear only of improvements in carding, if there be any; and as only those things are improvements which are the best of their kind for their respective parts of the operation, only those inventions shall be presented to you, which, as far as I am able to judge, have this character.

Naturally, as successful inventors in connection with many parts of the operations for effective carding, we think that the changes we have always offered are amongst the best of their kind, and therefore improvements. Moreover, if there be truth in the old saying that "imitation is the sincerest flattery," we have had a very large, costly and inconvenient *flattery-following* — if we may be allowed to coin a phrase — for many years past in England amongst both card-clothing and carding-engine makers. This evidence, therefore, we think points in the direction that the changes we have introduced at different times are valuable improvements. At the same time, gentlemen, that I give you this clear intimation that you are about to have our improvements put before you, and presented by myself, — a joint author and thorough believer in their value, — let me ask your strongest criticism of everything I shall say or advance upon the subject; and put aside for the time the kindly personal considerations which I am sure you would wish to accord to me as a comparative stranger among you. As one of your late presidents — Mr. Richard Garsed — remarked, in your former discussion upon this subject, "Handle the subject without gloves." I invite you to do this, and strongly contest every inch of ground with me. We have, we think, achieved the highest results ever known or expected in connection with carding; and there is ample evidence of this by the revolution going on in English carding to-day. We may be mistaken in our idea in what our appliances will do;

and if so, the sooner we are undeceived the better. To this end, therefore, I can only say follow my theories very closely, and "trip me up" at every point where there is the least chance. Earnest and strenuous opposition has taught us many things of exceeding great value, and your strenuous opposition is what I plead for. If with this you will bring your knowledge to bear upon the question, we shall advance many paces towards that we all so much seek after, viz., the truth.

The first part of my subject is described under the general title of carding. This operation is undoubtedly the vital one in connection with the spinning of yarns. There is no other in a cotton mill on which so much depends. Carding being well done, facilitates and smooths, most wonderfully, the paths of every subsequent process. Its importance is evidenced by the expressions, common amongst spinners, relating to its value, such as: "Show me a man's carding and I will tell you if he is a good spinner;" "The profit is either made or lost in the card-room;" and so on. Such expressions are common on our side of the water, and I have not the least doubt that you have their equivalents here; nor do I think that these expressions are exaggerations of the importance of the case. I have in my travels and examinations of some of the best spinning mills in England and the continent of Europe, always found that the most successful firms are those who paid most attention to their carding, and seemed to think no labor too expensive which would give them a better result there. "But why," I can fancy I hear some one say, "do you dwell upon this?" "We all admit everything you advance." Many times have I heard this said in England by spinners whose carding was in a perfectly ruinous state. My object in calling attention to the question, is to point out that whilst almost every spinner professes to see the immense importance of this branch of his operations, so very few seem so true to their convictions as to force them into an excellent method of practice. In this respect I am quite certain that, up to within the last few years, there are many firms in our country, spinners of what are

called "Oldham Counts," who are very much behind your spinners of the same kind of yarns here. No doubt your cotton, is, as a rule, of better quality; and your carding is most expensive and costly; but I am quite sure your qualities of certain counts have been, and are even now, in many cases, superior to much that is produced for the same yarns on our side.

What, may we ask, has been the reason for this disparity between the belief of a cotton spinner and his practice in regard to this vital operation? Our reply is, undoubtedly, the immense cost and labor in the way of constant supervision, etc., to keep the card-room production in anything like a satisfactory state. This immense cost and labor, we venture to affirm, has been owing to defectively constructed and badly made machines; and a clothing, which, by the incessant grinding and stripping of it, was constantly changing its character and wearing out, not only itself, but also the lives of the men who had those unhealthy operations so often to perform. Imagine the labor of grinding the wire four or five times each week and stripping out four times a day, as under the old system, and you will no longer wonder that carding was what it is, and has been, for so many years past.

With respect to the operation of carding, as performed by the carding engine, let me call your attention to what I think it is; or, in other words, how the work is done. Permit me to say in passing that I have never heard any cotton spinner approach the subject in this light, neither have I met with any theory of how this work is done in any printed book treating on the subject, or ever heard it handled by any teacher in any technical school of cotton spinning. It has evidently been much avoided, as being a very obscure performance. This, I imagine, was the opinion of many members of your association who took part in the recent discussions. Questions about the work to be performed by the flats, — whether they were only for carding or for holding the dirt, and carding; the reasons why the carder grinds his wire; the best kind of point on the wire

for carding; etc., — gave me the impression that the work as performed by the carding engine was either not very clearly realized, or the questions were put to see what could possibly be brought out. At first sight — indeed after considerable thought — "carding," I must confess, seems rather an obscure operation. It is very different from combing, which almost anyone can understand; that being a distinctive and positive process. Still, we think carding is quite understandable, so to speak; and we framed our theory of to-day many years ago, and have held and worked upon this theory up to the present time.

In the carding of cotton we have two principal things to accomplish: To separate, and draw out the fibres with the least fatigue to the material; and to eliminate all the natural dirt. The cotton as brought to the card is only in a partially opened state, and an examination of the crossed, twisted and comparatively matted fibres, will show that our task is not an easy matter. We have the taker-in (in your cards I know you have mostly worked without this roller), cylinder, flats and doffer. The feed-rollers slowly wind forward the cotton to the taker-in, which quickly covers itself with a thin film. The cylinder being set quite close to the taker-in, and the speed of the former greater than that of the latter, with the position of their wires set in certain relations to each other, the card cylinder snatches the thin covering of cotton from the licker-in roller. Owing to the more opened state of the cotton *now* on the taker-in, and the contact of the opposing forces of the two organs, the cylinder receives the cotton bedded in and laid well between its wires, but still with certain portions of it projecting above the surface. The revolution of the cylinder brings this projecting cotton into contact with the closely-set wires of the flats; the contest then goes on between these two forces where, no doubt, most of the carding is done. It is this point, moreover, to which our efforts have been directed, where lie the different theories, and where most of the evil has originated, according as these theories have been correct or otherwise.

I have stated above that from the taker-in the cotton is taken by the cylinder, laid and bedded between its wires; and, in our opinion, the more effectually this work is done at this part and in this manner, the better will your carding be. This is on the assumption that the other parts of the card are as fit to do their portion of the work as that commencing just after the taker-in. It is well known to those who have tried the experiment, that, by proper taker-in power, the cotton can be not only well opened, but to some extent carded, and much of the natural dirt got rid of at this part of the operation. The more effectually this work is done, assuming that the clothing of the flats and cylinder are of the right kind, the less will be the number of clots of cotton laid on and lying on the surface of the carding cylinder. We believe that the cotton, being properly prepared by the taker-in, should be, for the best carding, laid, if possible, between the wires of the main cylinder,—forced in so to speak,—the smaller the quantity lying on the surface of the cylinder the better. The centrifugal force of the cylinder will cause the fibres of cotton thus lying irregularly amongst the wires and clinging to each other, to lash out; or fly above the surface. This cotton in thus passing comes into contact with the wires of the flats. The cotton thus flying out with the centrifugal force of the cylinder passes, one after another, the opposing wires. The entangled fibres are caught, or combed at, by flat after flat in their short and rapid journey through the small space from taker-in to doffer; snatched now by the large cylinder and taken back again by the flats, according to the difficulty of separating and straightening them out; until, by the time the cylinder has made a third of a revolution, many of them are separated and freed from the influences of their neighbors. These fibres, being thus separated, are the lightest and most easily fly out from the cylinder; they are consequently thrown up above the surface, being "carded;" and at the point of "set" between cylinder and doffer, those freed and carded fibres,—laid hold of by the latter,—are doffed off as "sliver" by the fly comb. The natural dirt is

freed from the cotton in proportion to the opening power of the card; some portion going into the cylinder wire, but most of it thrown off and bedded between the wires of the flats, the place to which, if possible, it ought to be driven.

These being our ideas of how carding is done, we have come to the conclusion that some theories for the beginning part of the operation of carding are erroneous. We think that these theories, and the practices built upon them, are the results of defective construction of the machines and the other appliances to do the work. Take as an illustration the idea that the commencing flats of a "Wellman" card should be set some distance off the wire of the cylinder; and the use of very coarse wire and open set clothing for covering those same flats. This practice would no doubt produce the best result in carding cotton on this particular machine, the reason being that the machine and clothing are defective; but remove the mechanical defects, etc., and you come to a truer practice. The above is what I should call surface carding, or in this case, expediency-carding. The workers have done that which they thought best to produce the desired result with the appliances they had. Of course, nothing else could be done; for the spinner must look for the highest practical result from the machinery he has in his mill, and must adapt his practices accordingly. Physical is like every other form of error. If there is not a true foundation, the structure will soon show its weaknesses, and is ever after giving much trouble and labor in the way of supports and bolstering up, to give it a title to existence.

In addition to defective construction, the faults of carding engines have been weakness of build. The machine would not run at a decent speed without vibration or something shifting out of its place; untrue and unbalanced cylinders and doffers, and things of the same kind; in the clothing, the wires so soft as to fall very quickly out of position, and scarcely any space between them for the entrance of the cotton. For the best carding all the flats, — back, as well as the front, — should

be set as close as possible to the wire of the cylinder without touching. Neither with a properly made card need there be any graduation in the counts of the wire of the flats. The stronger is the build of the card, the firmer is the clothing; the more rigid are the flats fixed all over the cylinder, and the closer is the "set" of every organ throughout the machine, — so close, indeed, that even a staple of cotton cannot remain on the top of the wires, but must be forced between them if this were possible, — and the better will be the average result.

You will gather from these remarks more clearly now why I stated some little time ago that, at the beginning, the cotton should be properly laid; forced, if possible, between the wires of the main cylinder clothing. I hope you will see clearly and understand all the premises, or foundation, upon which we have so far proceeded in our labors, and upon which I shall proceed to-day. If we can agree upon what the operation is, or how it is done by the carding machine, there is no doubt we shall know what to aim at in order to bring forth the desired result.

The next question presenting itself is, how are we to obtain this desired result? This allows me to speak of what I consider to be the construction for the best card clothing. Here let me clear the ground a little by explaining what we are to understand by some terms in common use; I mean expressions as to forms of point — if I may be allowed for the moment to use a paradoxical phrase — the grinding or sharpening of wires, etc. I do this because, in reading through your recent discussion, I find you have the same ambiguity in these things which we have in our country. I come to this conclusion because I find one gentleman says he grinds to sharpen his wire, whilst another performs the operation to make it dull. Again, there were many questions as to the best point, whether a "needle-pointed" card is best, and so on. Let us first clear the ground upon the word point. We have such expressions amongst us as "long-point," "short-point," "smooth-point;" and I have heard the expression, "a point a long way down

the sides." Euclid's definition is, "A point has neither length, breadth, nor magnitude; it has position only." This is truth, and nothing can be better for our purpose. The impossibility of attainment we all know, but let us take it for our standard. You see there can be no "long" nor "short" points, nor a "point a long way down the sides" in the sense the speaker intended it. Neither can there be a "smooth" point, unless, indeed, we consider that point "smooth" on the end of a wire which approaches nearest to the mathematical definition. The term needle-point we might accept for our purpose if a little ambiguity as to its meaning be cleared away. We want to distinguish the difference between a fine point — because this is our idea when applying the term to card wires — and "needle-point." When a person speaks of needle-point, there is no doubt he means "fine point," or small end surface at the extremity of a wire; such small end surface being produced in the same way as it is produced on a needle, viz., by commencing a little way down the wire, and removing the material equally all round from this commencing part to the end, in a tapering manner, until the *point* is found, if possible; something "which has position only."

Let us, however, strike out of our minds the idea of the point produced by tapering a wire equally all round like a needle, and take, for our theoretical standard "point" to be aimed at, that which "has position only;" and for our practical "point" that position at the extremity of a wire which has the least end surface. To put into an easy form of expression what we can obtain, let us speak only of "fine points," which we will understand as meaning the small end surface at the extremity of the wires: these words "fine points" being only used, to express the degree of our advancement towards our standard; that which "has position only." By understanding and adopting this you will see at once that we clear away such expressions as "long" or "short" points and "smooth" or "needle" points. From the foregoing considerations we may safely make the following deductions: "Fine points" on the

wires are best for carding; which "fine points" are produced by tapering the wires, commencing as far down the teeth as is consistent to retain the proper strength of the root, and removing the material from the back and sides until you fix a point on the wire, if possible, coincident with the termination of a straight line which could be drawn inside the card tooth, beginning at the bend, and finishing at its extremity. We have worked on this theory for our improvements in card clothing, and the results so far have testified to its correctness. From this we can easily formulate an answer as to the best kind of clothing as "That card clothing which, having the same number of points to the square inch as another, has the smallest wire end surface, and the greatest space between its wires for the entrance of the material, with an equal or greater strength of the wires at the root." Such card clothing to be so constructed as to retain the first-named conditions as long as possible with the ordinary grinding treatment in use at the mills.

Our first patent in card clothing was taken out in the year 1870. This was for the use of wire for card-clothing manufacture which had been flattened from the round form by passing the same through and compressing it between hardened steel rollers. This operation produced a wire with two broad flat sides, and two smaller ones the section of a circle. Nearly this shape had been in use many years before this time, as "angular," "oval," since re-named under the term "double-convex." These shapes are as follows: —

A distinctive and valuable feature of our method was the easy manufacture and production of a definite shape. This

wire being produced by the plain surface of hardened steel rollers, and giving the valuable quality to the wire of *greater compression.* This clothing was a great success, and in iron wire cannot be excelled to-day. We, and our licensees, made about two million dollars worth in twelve years. It brought about many imitations and colorable infringements, and marked a new point in the career of the card trade. This was the beginning of our card-clothing inventions, and the magnified sketches here given show that we get "fine points" with ordinary grinding, and plenty of space in the working direction for the entering of the material; also extra strength of the wire at the root.

Our next patent in card clothing, that of making it from a continuous length of hardened and tempered steel wire, and taken out in 1878, is one which is rapidly changing, and is certain, eventually, to revolutionize the entire card clothing trade; if taken in conjunction with our other three inventions, — those of 1878, 1880 and 1885, — all, means of producing a clothing in which with ordinary mill usage, "fine points" can always be got and retained for the longest possible time. The hardened and tempered steel wire card is undoubtedly one of the most valuable improvements in connection with carding which has ever been presented to the trade. The quantity being now made, and its comparatively rapid adoption all over the world, are proofs of this. It is a very wide-reaching improvement also, and has given many other things a *locus standi*, which could not, without it, have lived.

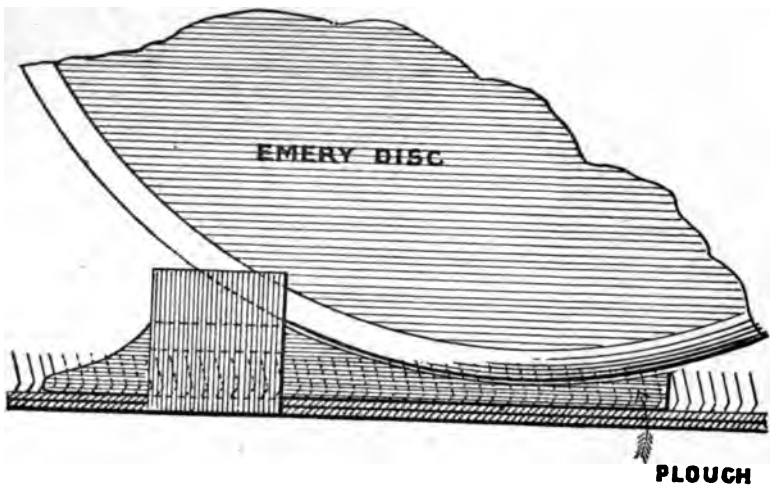
The first of the methods for the tapering of wires, — of which I here give illustrations, — a plan of grinding away, or reducing the wire at the back part of the tooth, beginning at the bend up to the point, is done at the card-making machine

by abrading portions of the wire at intervals. The wire is then cut through the centre of the reduced parts before being bent in the tooth form.

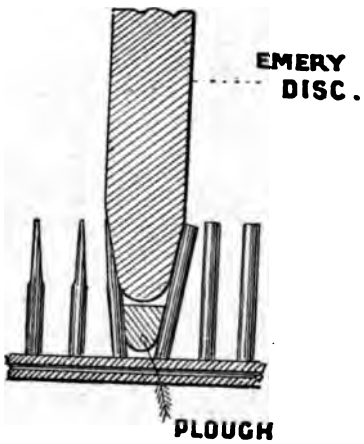
For convenience of manufacture, this wire was flattened a little. This, we found, was a step in the right direction, and led us to further study and experiment, by which was produced a method of producing card-wires as published in our patent of 1880. This operation, which is done after the card clothing is made, is another and better method of reducing the wires of card clothing from the ends down each side; in order always to have fine points with the ordinary grinding treatment at the mills.

The success of this, as well as the hardened and tempered steel wire card clothing, produced an immense crop of infringers in England. We have been put to very serious cost of money, trouble and anxiety, thereby, to defend our rights. Both inventions were strenuously opposed for the first two years or so by nearly the whole trade; and finding at last that they were bound "to go" in spite of all opposition, the old plan was adopted.

Respecting this method of reducing the wire from the bend up the sides, I feel it due to you and ourselves to call attention to the sketch given by Mr. Leigh in his paper and published in your Association report. This sketch is very far from being correct. It is likely Mr. Leigh was deceived in what he saw, or had not given the matter sufficient examination to give what were his impressions at the time he wrote. What Mr. Leigh calls "Sykes' method," is our own. The same kind of thing was done by Messrs. John Whiteley & Sons, Halifax; and we have only lately settled the litigation which was going on against them and another English firm, for infringement of patent. Our grinding down the sides is produced by using emery discs, which run between the wires or spaces of the teeth. These discs are guided by a "plough," which makes a path for each one, fixes and holds the wires for the action of the grinders. These "ploughs" are exceedingly valuable, because they give a more definite and controllable

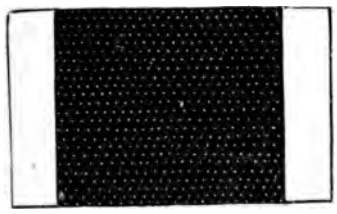


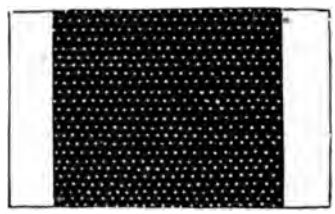
GRINDING METHOD



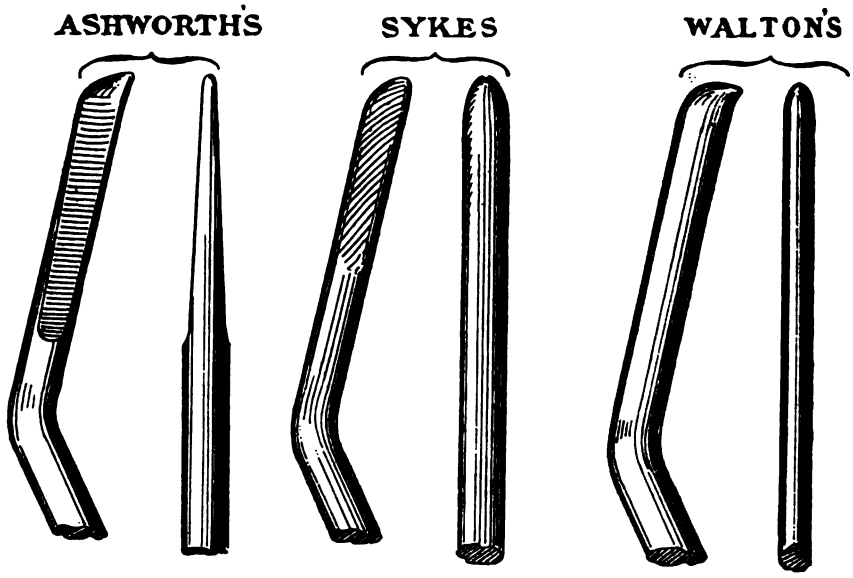
cutting action. Indeed, with our machinery we can reduce to any extent, and as deep down the tooth as we desire. It was after this method had been in the market over two years, and the specification published, that patents were taken out by the two firms above, for what they called their process. There was no practical difference between the two. Instead of running the card clothing as we do, over a flat table underneath the grinders, they put their clothing on a cylinder, and the work was done "by causing the cylinder to rotate slowly, and by, at the same time, traversing the revolving grinder or grinders at such a corresponding speed as shall keep it or them in the furrows, so that they shall not cross from one furrow to another." To show how plain and gross these infringements were, I have here given their processes in the exact words *as described in our specification.*

As steel clothing upon which "fine points" can be easily produced is likely to be much more generally used here, it is important that you should know the value and difference of the various kinds which may be offered. I therefore give you sketches of the appearance of various wires after each have been ground and are ready for work, because *then* and *there* you want the best form of point.





Mr. Leigh's sketch showed "Sykes' wire" tapered all round like the end of a sharpened lead pencil. No doubt the intention was to show the wire tapered the same depth down the back and round each side, leaving the front of the tooth from bend to point as a straight line. My objection is to the depth



ENLARGEMENTS OF CARD TOOTH POINTS

of taper as there given. Nothing like it can or is produced by this plan. It is comparatively a hap-hazard "fumbling," or averaging process; producing an appearance, to sell, and make a spinner believe that he is buying a clothing of a kind which a couple of years or so of usage will show him it is not. Now this is a very serious matter, because our experience has taught us that some form of reducing the steel wires is quite essential to make it a success. It is for want of this that even to-day we hear of failures, and part failures, in the use. If this be true, there can be no question of the value of knowing the difference of reduced or tapered card-wires. It is the more important to name this now, because clothing pointed without the ploughs will now be sold bearing royalty to us, and to this extent connected with our name. It is a little cheaper than the clothing reduced with the ploughs, and is also sold with the finished point. Messrs. Whiteley & Sons, Halifax, Messrs. Wilson & Ingham, Liversedge, and Messrs. Sykes Bros., Lind-

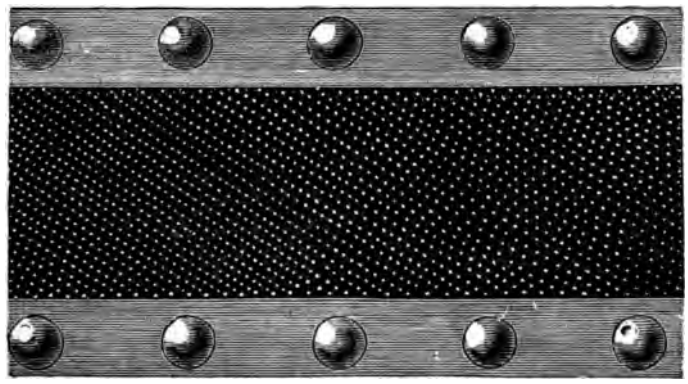
ley, and Messrs. Horsfall & Bickham, Manchester, have license to make this clothing. The two former have machinery, also; and the two latter will get the machinery as soon as they find a demand for the clothing. Spinners have often been deceived through this inferior clothing being sold with the finished point. It is thus made and sold because the uncertainty of the process will give no other form to the wire. In this case, however, the sellers have attempted to make a virtue of necessity, — they have had the boldness to say "this is a needle-point, and Ashworth's is not." Notice the quibbling on the words needle-point. The important question is, which clothing will have the finest points and most clearance after it has been put on its proper part of the carding-engine, and ground a number of times by the ordinary process? For a reply to this, let some of your spinners who have this clothing, which has been used and ground about six or eight times, examine their wires and see how much of the tapered part of the card-tooth is left. Any man, who has paid the least attention to the question, can at once see that no wire ought to have its finished point put upon it *until it is fixed upon the part of the card where it is to remain and work;* as a cylinder fillet on its cylinder, and a doffer fillet on its doffer. Putting aside the small unevenness of the parts on which the clothing is fixed, there will be the different position of set of the wires produced by the different tension, etc., when the clothing has been pointed on one cylinder and then taken off and put on another; and this latter the one which requires the surface of the clothing perfectly true, and the wires as nearly as possible quite evenly pointed. Let me ask you to remember, then, that we never put finished points on our clothing until it is on the part of the card on which it has to work and remain, — that our preparatory process to this is tapering the wires deep down the sides. Another and still further advance in the way of getting "fine points" on the wires is that produced by our hand-finished pointing process, patented in 1885. I have said that from the shape of our wires "fine points" are produced on them by

the usual grinding process. The finer the points, however, the better are the results; and this hand-finishing process is done to the cylinder and doffer clothing of our own make of cards after the clothing has been wrapt on, trued up and pointed by grinding with the ordinary roller. After the first trueing, the ends of the wires can be *easily seen*, and we want to make them hardly distinguishable. To do this, our erectors use an apparatus which our engines have been constructed to receive, and by the employment of which a quickly running emery disc is traversed between each separate row of wires until we get the required "fine points." This is a most delicate operation, but it is done very effectually; and there is this advantage, that it can be used years afterwards, if need be, at the mills for reducing or cutting away the wires down the sides. There are pieces of clothing finished in this way on the table here at the pleasure of everyone who wishes to take a sample.

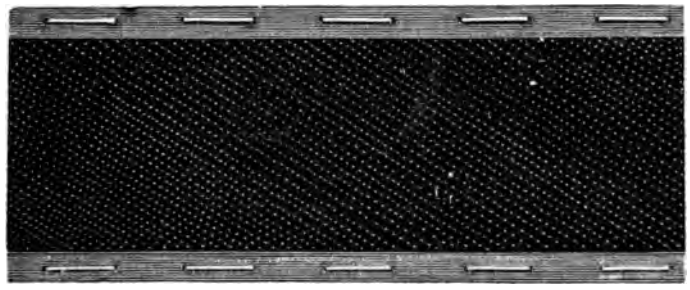
I now propose to call attention to our improvements in carding engines. We have, for years, had faith in the revolving flat card as the machine of the future, especially if certain defects of construction could be remedied. To remedy these defects we have applied ourselves very assiduously for the last twelve years. As Mr. Leigh stated in his paper, "the machine is the same in principle as when it left his hands (referring to his father) in the year 1857;" and then again in the same paper, "it is quite true that minor improvements have been made, etc., but the principle remains the same." No doubt, in his estimate, Mr. Leigh left out of his calculation, as possibly not within his knowledge, many of the improvements I shall bring before you to-day. Certainly no important change in construction of this machine has been made by those from whom spinners might have expected it to come, viz., the English machine makers. They have always taken the line of obstructionists in this matter. The first important change was effected by ourselves in 1878, by the introduction of an improved method of securing clothing to the iron flats, and the execution of this work by machinery. This was introduced in order to

get a better and more secure fastening than that afforded by hand riveting; and to economize the waste space.

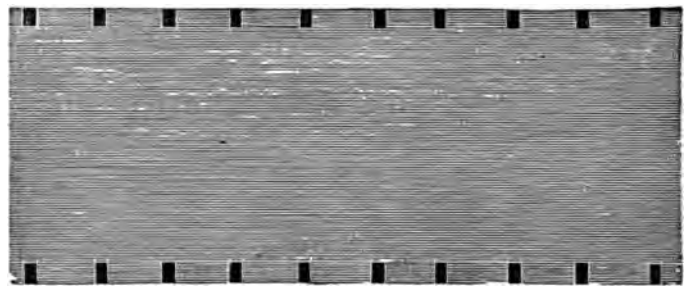
This invention was the means of introducing the "narrow, flat card," as it was for a long time called in England. With a cylinder 50 inches diameter, we were enabled to get 100 flats of the same width of wire, where, before that time, there had been but 67; and 37 working, as against 25. This was strenuously opposed by the leading English machine makers; all of whom to-day recommend one form or other of narrow flat. We give a sketch of what the fastening was in 1878, and our own method:—



OLD METHOD OF HAND-RIVETING.



ASHWORTHS' PATENT MACHINE FASTENING.

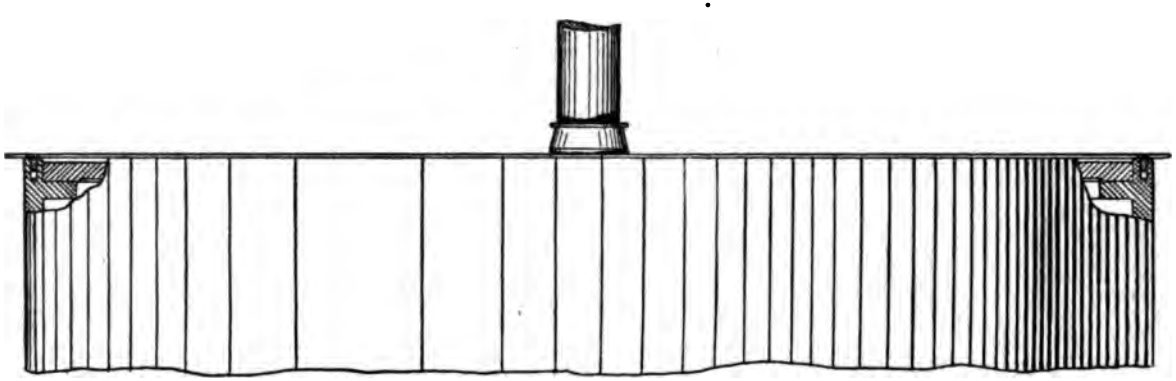


This gave a great impetus to the revolving flat card, because its power was very much increased by this very simple change. Up to that date the card was in construction exactly as it had been left by the late Mr. Evan Leigh.

Another important improvement to the card, patented by us in 1880, is our sliver selvage system. This is a valuable arrangement by which almost perfect edges are obtained to the sliver, and dangerous side waste is altogether prevented. This improved selvage system effectually cures an evil which has been always considered one of the most troublesome things at the doffer of a carding engine; and it effects an economy to the extent of several inches in the width of the machine itself. Considered in connection with the revolving flat carding engine, this economy in width is much more important than appears at first sight. For instance, our 37-inch and 44¼-inch wide cards will work laps from 40-inch and 50-inch scutchers—that is, though but 37 inches and 44 inches wide, the former is a practical 40-inch and the latter a practical 50-inch wide engine, because they will card laps from 40-inch and 50-inch scutchers, respectively. These carding engines are made to suit the width of the laps which the scutchers produce; and contrary to the old method, which demands that the wire surface of the carding engine shall be several inches wider than the lap itself, the wire surface of ours is about an inch narrower than the lap. From this follows a most important result, one which everyone ac-

quainted with the niceties of the revolving flat card will quickly appreciate. Owing to the narrowness of our engines compared to those of the old style, we get the following differences in the length of the iron flats: The flat of our engine which works a lap from a 40-inch scutcher, is 5½ inches shorter than one on an ordinary 40-inch wide card; and the flat of our engine which works a lap from a 50-inch scutcher is 8 inches shorter than one from a 50-inch of the ordinary make. In other words, we are to-day producing a carding engine which has a working-wire surface equal to an ordinary 50-inch wide card, and yet it occupies 4 inches less width space than the usual 40-inch; and the former has a flat only 1¾ inches longer than that of the latter. Seeing how essential is an extremely fine or "close set" to the production of the highest possible quality of carding; and remembering how much this "fine set" is interfered with by any deflection of the flat itself; the value of having a flat short, as well as constructed so as to avoid deflection, will be quite plain to every one who has considered the subject, and made such mechanical tests in connection with it as the importance of the case deserves. Hitherto, spinners have decided against a 50-inch wide revolving flat card, because the flat was so long as to give it too much deflection. This objection no longer holds good, because, owing to the different construction of the flat used on our engine, and its comparative shortness, as explained above, the flat used on our 50-inch engine deflects less than the 40-inch one which is used on the ordinary revolving flat card. We have made 140 of our engines of this width for the new mill erected by Messrs. I. & P. Coats, Paisley. And many other large and well-known spinners in England and Scotland have adopted the same width also.

The next improvement, — and it is *the invention* of our card, — is its "non-flexible bend." The somewhat unusual name for the description of this part of our card, "non-flexible bend," is at once suggestive and carries a fair idea of its origin to all those knowing the ordinary revolver, though it may strike



SLIVER ARRANGEMENT

some persons as being a little singular. The term "flexible bend" has always been the feature and distinguishing characteristic of the ordinary flat card. This part, and the method of applying a chain for carrying the flats, were the invention of the late Mr. Evan Leigh; but the principle of revolving flats was the invention of the late Mr. Smith of Deanston; and the first revolving flat card was made by him at the concern with which he was either then or afterwards connected — Messrs. Finlay & Co. — they having still the two same mills at Catrine and Doune, in Scotland. About two years ago, we replaced these first made and original revolving flat cards with ours; and purchased one of the original ones as a sort of historical connection between the past and the present. We shall be pleased to show this at any time to any gentleman desiring to see it. "Flexible bend" is the title which has always been used to describe that portion of the ordinary revolving flat engine on which the flats rest or slide. This "flexible bend" consists of part of a circular cast iron ring nearly the diameter of the carding engine, turned and trued on the top, and tapered from the centre, underneath, towards each end. They are fixed, one on each side, of the card frame; and have three or five "setting points," according to the different notions of the machine makers. These "setting points" being connections, or attachments of the bend, by the means of which, with screw and nut, these parts of the circle or "bend," are compressed or expanded; in order to get and, if possible, keep, coincident with each other, the outside of the wire surface of the cylinder and the flats, when the lines of these circles diverge from each other, owing to the wear of their wires through grinding. The difficulty of this "flexible bend," with its joints and its setting points, was discovered early in the card's history. Unless the flats were correctly made, — all exactly alike, — and the "bend" fairly well constructed and true, and a workman to manipulate this bend with very great skill and care, the result was a comparative failure. The "Wellman," or some other form of lifting flats, often produced better results because

they were easy to manage, owing to the power of setting each flat independently. To compress and expand part of a cast iron circle like this "flexible," always retaining a perfectly circular form, is an extremely difficult task; but even if this could be done, it is an utter impossibility for any workman — skilful though he be — so to take in and let out all the setting points at each side of the card, that when the circles are expanded or contracted they shall *perfectly coincide* with the surface of the cylinder. Even if this could be effected, there is the serious fault of the weight of the flats deflecting the bends between the "setting points." This fault is now admitted by the device of the makers of this card; of putting crutches or supports, to bolster up this weakness of the "flexibles." Now, seriously, is not this application of supports a plain admission that this principle of flat setting is altogether wrong? If we apply supports to any other structure, or bolster it up, it is always because the building is either defective in construction or owing to bad workmanship. There can be no question of the "flexible bend" of to-day being better made, — there is no fault there. This article has for some little time past, and is even to-day, being doctored, operated upon and fondled, in one form or another, by almost all the English machine makers. Each maker has his own remedy to prolong the life of this interesting mechanical offspring. One gives it crutches to support its lameness; the next has a sort of averaging-process cure, and says in fact that "though our offspring is constitutionally weak, I have by my care minimized its constitutional defects by this averaging-process cure method, so that the weaknesses and faults will not be discernible." A third declares, that by excessive care in training his progeny by giving him a true start at the commencement of his journey, his inherent defects will not trouble him. Whilst the last, — quasi-scientific, — tries to dazzle the mental vision of the purchaser by throwing at him a flash of electricity, and thus vainly endeavoring to revive the now regarded weakly and declining individual into prolonged life, by an electricity dodge. They all know

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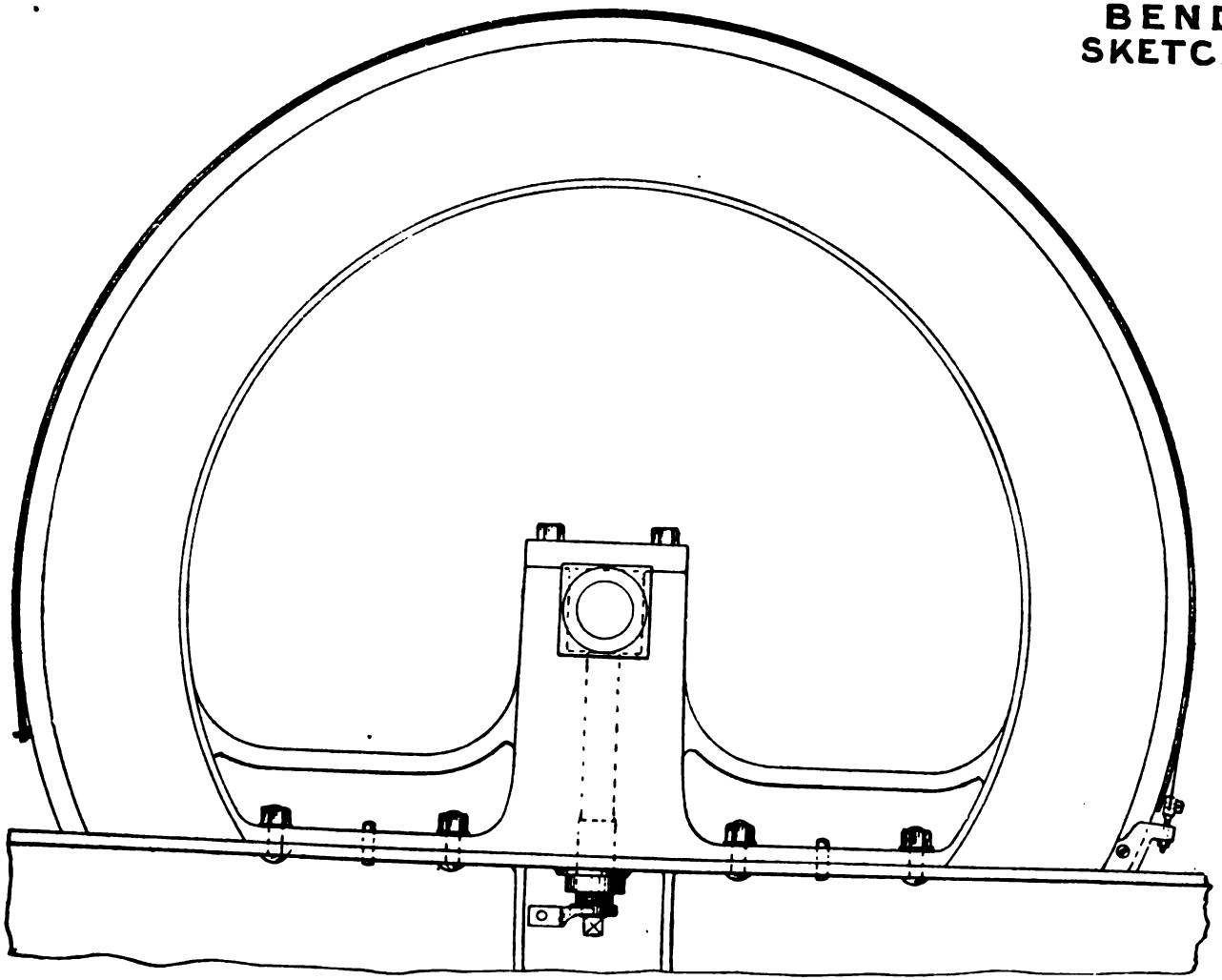
BEND
SKETCH



quite well, from experience, the careful and watchful treatment which this "flexible bend" requires at their hands, as well as from the workman into whose hands it falls; and so they apply all their skill to fit it for something, which, owing to mechanical defect, it can never be made to accomplish. When it is considered that most of the carding with the use of the revolving flat engine is effected between the flats and main cylinder; and if a flat be doing its work properly, it must be within the distance of a piece of ordinary wrapping paper from the cylinder wire; the difficulty of our task is plainly recognized.

In place of the above we bring before you to-day our own arrangement for setting and keeping the two circles of cylinder and flats coincident. Believing that we have only given a true estimate of the faults of the old bend — its flexibility, etc., — and have put our finger upon the weak places of the machine; we show to some extent by the title what our own bend is, in stating what it is not, — "non-flexible." Herewith is given a sketch of this new bend.

The path, or circular rail, on which the flats rest or slide, is formed by turning the top of the frame side; to which is cast the pedestal receiving the bearings in which the cylinder revolves. These bearings, having been bored and carefully fitted into the pedestals, have a mandrel fixed in the hole, and then the bend is turned in a special lathe; which makes a path on which the flats slide the section of a circle, having the central point of the hole of cylinder bearing, at its centre. The cylinder having this bend placed by construction in the centre of the circle, it must, for theoretical correctness, be kept in this position. To effect this, and compensate for any wear which may take place, we employ what we call pedestal screws, which go through the frame underneath the cylinder bearings; by the use of which we can raise or let fall the cylinder in a direct vertical line struck through the centre of a circle. These screws are one and three-eighths of an inch in diameter, and carry brass discs marked with lines to give the quantity the screw is

turned. A pointer fixed on the frame points to the lines on the disc, and the turning of the screw from one line to another represents the cylinder raised or lowered, as the case may be, one-thousandth part of an inch. These pedestal screws, though *principally* to compensate for wear, are also used for setting, and furnish an easy and valuable means for this; though this use of them is contrary to the strict theory of our plan. I have stated previously that the closer the set between the flats and cylinder, the better are the results. Now, imagine a case where a man grinds his wire, say four or five times. This man knows that there is a very small distance between the wire of the flats and cylinder; believing, at the same time, that if this small distance can be taken up it will give him a very important result in his carding. No person, however, having knowledge of the difficulties of manipulating the "flexible bend" would attempt to disturb it to take up this very small quantity; fearing lest, after much labor with his six or ten "setting points," he would leave off with the card in a much worse condition than when he commenced. With this arrangement — without even stopping the card — the screw may be turned to represent the distance of one or two lines on the disc, and the result is obtained with about two minutes labor. We use these screws for setting, therefore, until about four or five lines have been passed. The cylinder is then out of its centre about a two hundred and fiftieth part of an inch. Having gone so far with this plan of setting, the top steel band is taken out; and one so much thinner is put in its place as will give the equivalent for the four or five lines on the disc. The screws are let down to zero, and the cylinder is again in the centre of its circle. The above mention of the steel bands suggests the plan employed for increasing and diminishing the diameter of the bends. This is effected in a very simple manner by laying on the top of the circle four or five hardened and tempered steel bands or ribbons, flattened each to a known and definite thickness, — which thickness is indicated by a number on each, as twenty-six or twenty-seven band, the difference of thickness being equal to one

five-hundredth part of an inch, and so on progressively. If, therefore, we have put our cylinder out of centre by four lines of the disc, and the top band should be numbered twenty, we require to change this for one eighteen; and bring our cylinder disc back again to zero. These bands are quite accurate in thickness, and we get a circle represented by the top of the outside band as true as that of the bend underneath. We have here a few of these bands at the pleasure of any gentlemen wishing to examine or gauge them. These bands have a hole at each end; and the plan of fastening them on the top of the bend is by placing them one over another on a stud screwed into the back part of the frame; a small pin going through the end of this stud to hold them in their position. A screwed spindle attached to the end of the top band goes through a small bracket fixed on the doffer side of the card. This screwed spindle carries tightening nuts, by the use of which the top band can be drawn down, thus tightening also and fixing the underneath bands in position. Nothing has to be moved from the card to change a pair of bands. This can be done as soon as a man can set his flexible. I wish to say here that the great value of this plan of setting flats is its extreme simplicity and manageableness. This is the opinion of all spinners who have our cards in use. We can by this method increase or diminish the size of the circle by the smallest positive quantities, without risk of disturbing the concentricity of one circle with the other. There can be no spring or vibration, even when the card is working at a very high speed, because the flats rest on a path made by a casting eight inches deep by five-eighths of an inch broad. There is not a single setting screw or joint about any part of the bend, hence nothing can get out of order; and there is no danger of the rapid depreciation which is so often known to show itself in the employment of the card with a "flexible."

Another improvement on this machine is the scientific method of fitting all its covers, each one being made concentric to its own part; they are also made of thick steel, polished

inside and out, and carefully finished, — very different work from the rough wrought iron ones often employed. As a result we avoid all appearance, at the doffer side, of those clots, or accumulations, which so often spoil some of the best carding. To show how these covers are fitted, we will take, for example, that on the doffer. That part of the card carrying this is cast to the doffer pedestal, and the part on which the cover rests, is turned with a mandrel on the doffer bearings, in the same way as are the cylinder bends. Hence a cover placed on this turned portion of the doffer pedestal, must be concentric with the doffer itself; and there is only left just sufficient space between it and the wire, for the carding of the cotton. The same idea is carried out for every cover of the engine. As a consequence, an accumulation never appears in the web; there is no room for it to grow. Another appliance on our card is the simple slow-turning apparatus for actuating the cylinder and doffer when grinding. Also, our special grinding rollers, and emery bands for covering same.

There is also our valuable plan of automatic turning of cylinder when stripping. This is a very simple arrangement, and abolishes much heavy labor, tending also to the more effective clearing of the wire. It is very heavy labor to turn a cylinder in its working direction when fairly full of cotton, and it is seldom turned slowly and regularly enough for the purpose. By the new plan of automatic turning, the manual labor is abolished, and a uniform slow motion is obtained.

There are still many things I could introduce to you, but the length of this paper forbids. I must content myself with simply naming some of the rest, as the "Patent automatic oiling fly comb box," the "enclosed brusher strippers," for cylinder, doffer, and flats; the "patent flexible dust cover for flats," the "new patent construction of main cylinder," the "safety steel doffer cover," etc. Let me remark in finishing this part that our card, as left by us complete and working at the mills, contains twenty-two patent inventions. Every detail of grinding, stripping, oiling, etc., has been fairly worked

out with the result that this machine is almost an automaton. There is hardly any cost in labor or attention. Grinding is only needed once or twice each year, and stripping about three times each week, — many firms are working this card with even less labor than this.

A few words with regard to the capacity of this card for work. The quantity and quality this engine will produce are not to be believed unless experienced or known to be true from reliable knowledge. A spinner who has had the cards at work in his mill for nearly three years, states, "the quantity and quality of work produced by one of these engines is almost incredible; and only to be believed by those who have had them for some time at work." I will add a letter on this head from one of the largest and most successful firms we have in England.

FLAT MILLS, WALTON-LE-DALE,
PRESTON (ENGLAND), April 29, 1887.

We have pleasure in bearing testimony to the efficiency of Messrs. Ashworth Brothers' Revolving Flat Carding Engines. Early in 1885 we obtained one of their thirty-seven inch engines to test its capabilities; and, the result being in every way satisfactory, we, later in the year, gave them an order for thirty-six more engines. With these thirty-seven cylinders we replaced sixty-seven cylinders of other makes; and are now turning off 4000 pounds more sliver per week than with the sixty-seven; and producing 850 pounds of yarn per engine per week, of a better quality than that from any of our other engines and with a considerable saving in waste and wages. The change has also greatly economized the floor space of the card-room, thus enabling us to put in longer and more modern slubbing and roving frames. Altogether, we have a very high opinion of Messrs. Ashworth's engines, and have within the last few days given a further order for thirty-eight.

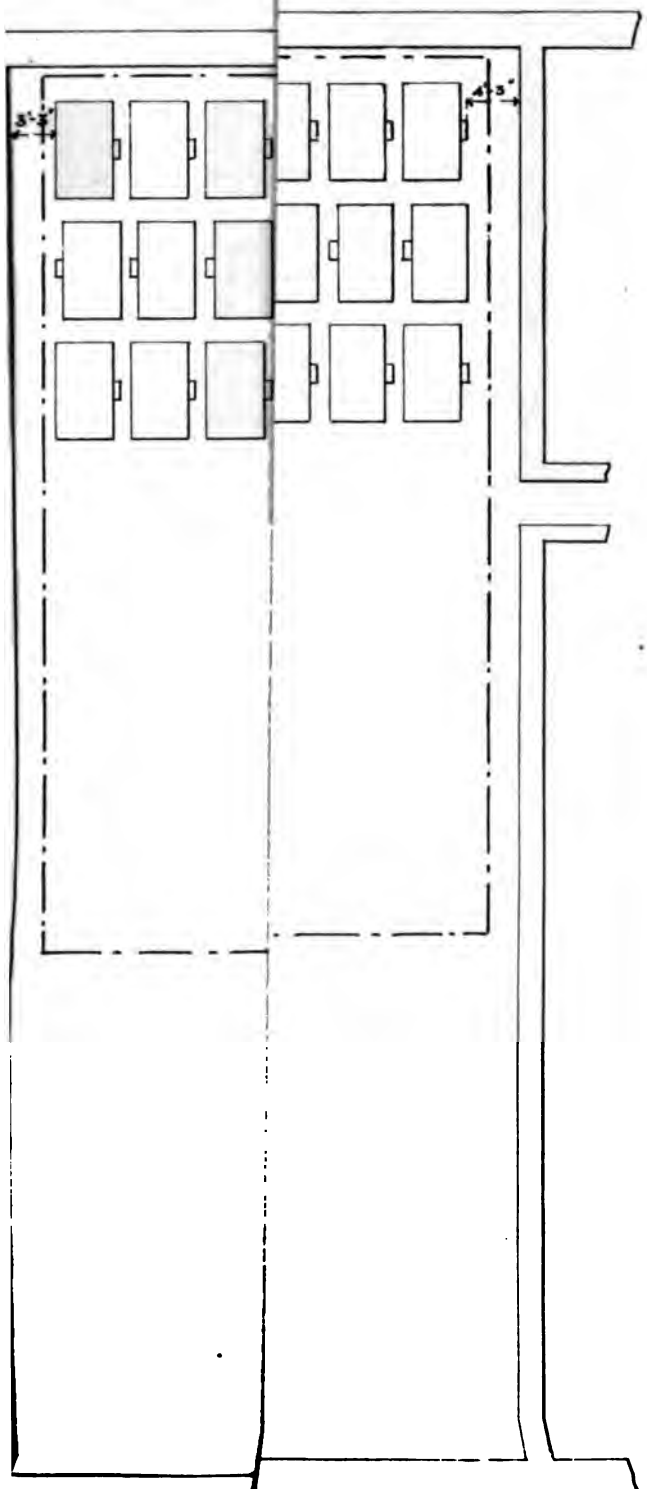
WILLIAM CALVERT & SONS.

I may say, also, that any spinner through application to me, can see a dozen other letters, quite as satisfactory, and equally complimentary; still, even with this evidence, I expect you will have considerable doubt until you have fully realized the

case for yourselves. When four years ago, we stated that this card would produce 750 pounds of excellently carded Orleans cotton in fifty-four hours, and with so little labor, and so small amount of waste, as is now found to be the case by experience, the statement was laughed to scorn by the leading machine makers in England. The reply was in effect, "It is preposterous, it can never be done," etc. This opinion, however, is now changed, and we find most makers saying that their card will, in production, "equal the Ashworth." It has not been seen yet, however; and unless the kind of argument which has been so much indulged in on our side of the water to prevent the progress of this carding engine, can turn a mechanical wrong into a right; can prove that complication is as valuable in a card as simplicity; or make people believe that in a machine so important as this, indifferent workmanship is equally good for the purpose as the very highest; the results our cards are producing to-day never will be accomplished with the present make and construction of carding machines.

On this point, I add a further statement: A large spinner, who has now about eighty of our cards at work in his mills, though he had the production of almost all the English machine makers working, paid us the very high compliment of saying that the engines we have made for him contained workmanship of a higher class than he had seen in connection with any cotton machinery. As expressed in the recent discussion, it seemed to be the opinion of some that we had done too much in this way, and made the card too costly. On reading your remarks on this head, we were led to think a little and examine the question; but our examination led us to make a resolve to improve even further in the direction of accuracy and workmanship which would endure. We found that every point towards perfection seemed to score and pay for the outlay, and to-day the machine made by us is even much in advance, in this respect, of those seen by some of your people in our country some two years ago. You have the opportunity of examining one of these engines now at the Boston exhibition.

Plan of ent Cards,
with 60 Hours.
The dotted nother firm to do the same Work.



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ASTOR, LENOX AND
TILDEN FOUNDATIONS

This card has no special finish, but is exactly as we turn them out. As we have some orders in, also, for mills in your country, I hope you will have the pleasure, very soon, of not only seeing them, but knowing the result of their working.

I have here on the table samples of filling, and of the cotton it is made from. This (No. 1) has been carded on a 37-inch wide engine at the rate of 850 pounds in 54 hours; clothing ground twice each year; cylinder and doffer stripped three times per week; waste made, 2.6 per cent. Also (No. 2) samples of common hosiery, and of the Surat cotton it is made from; produced on an engine 44 inches wide, at the rate of 900 pounds in the same time as above; grinding once each year; stripping three times per week; waste 3 per cent. Also (No. 3) samples of 60's filling made from the work of a 44-inch card; grinding three times per year; stripping once per day; waste 2.7 per cent. Samples No. 4, thread yarns carded, Nos. 32, 50 and 60; weight carded, 400 pounds in 54 hours; grinding twice each year; stripping three times a week.

Knowing how valuable and costly is space in your mills, we have taken the liberty to work out, from card-room sketch of the mill given by Mr. Leigh in his paper, the comparative space occupied by the cards there used for 70,000 pounds of yarn per week in 60 hours working; and the space in which we can put cards to do the same amount of work, equal in quality, and with half the cost of strippers' and grinders' wages; as well as with one and one-half per cent. saving in waste, compared with what is being done at the same mill to-day. (See sketch, Plan of Card Room.)

[Mr. Ashworth, here, with the use of models and full size drawings, gave the following description of several parts of the Ashworth card.]

Before the date I speak of there were 67 flats put on a 50-inch diameter card cylinder. The flats were all 2 inches in width, on iron, and carried just an inch and an eighth width of wire. You know they used very large rivets. This (a bar of flat)

has the clothing as tight as a board, so perfectly is it stretched; and we can stretch the cloth to any extent by our machine. As I tell you, we, by this change, got on 100 flats with the same width of wire, where before there were but 67, and 37 working against 25.

This bearing here is 4 inches wide, as far as I remember. We turn this bend with mandril in the bearing until the circle underneath the dark line becomes the section of a circle, with that — the centre of hole — as a centre. To carry out this plan correctly, however, we must keep this in the centre in which it has been placed by construction. To effect this we have two large screws let in through the frame underneath the bearing. We have a disc distance marked by lines, and a pointer on the frame pointing to the lines on the disc. The moving of these screws, as represented, from one line to the other raises the cylinder or lets it fall just one-thousandth part of an inch. That is, to some extent, or partly, for keeping the cylinder in the centre in which we place it by construction. Now the question is: How do we increase or diminish the diameter of that circle? We have on the top there a number of tempered steel bands which we use when we want to increase or decrease the diameter of that circle. Suppose it be a five-hundredth part of an inch, we take off the top band and put on one a five-hundredth part of an inch thicker or thinner. We can graduate that circle in almost infinitesimal and positive quantities, if we wish to do it. I will show you the regularity of these bands. I have heard a great deal said about these bands being irregular and getting out of shape. We have used them four years and have not found one out of shape or irregular in thickness. I have some of them here, and if anybody will step up here and show me how and where these bands are wrong, and put one out of shape, he will do me a service. Now we will undertake to change a pair just as soon as any man can set his "flexibles." We take off, for instance, that bracket. The other ends of the bands are on that side, and there is a pin to hold them on. We take out the pin, throw off

the outside band, put the pin into the hole to hold on to the remainder. Then there is a hole through the frame. We push the new band up through this hole underneath the old band, a man just pulls this with a string, the flats are turned around, the old band goes out and the new comes in. There is nothing at all taken off except these two brackets, and, therefore, there is very little trouble in the operation.

Now you see what we get rid of in connection with this setting. There is not the least vibration, there is not a joint about that card. We have no trouble whatever in keeping this card right. Although certain people have often said that the difficulty in manipulating these cards is that if anything is wrong they "have to send for Ashworth's men," and that to manipulate the machines a man should be very skilful, I assure you that it is not true. The machine is properly and so well made that there is no trouble about it. An American gentleman, and a spinner, called with me and asked a user of our cards about this matter. He replied: "Why, we have no trouble at all with these cards. People have said that when anything is wrong with the Ashworth's machine you must send for Ashworth's men, but there is no trouble about it, and we think we can set the card better than Ashworth's men." And I want you to show me any point where you think there is any difficulty about the manipulation of that card. In the first place there is little of it, no complication; and in the second place anybody can do it with ordinary intelligence.

I do not know whether it is necessary for me to read this part of my paper treating of the pedestal screws; perhaps I can do it by explanation. The point is this: We will take a man who has ground his clothing four or five times, and he knows there is a very little distance between his flats and his cylinder; if he can take up that small distance he will secure equivalent results. With the ordinary setting screws, on the ordinary card, no man would venture to take up this small distance by any "flexible bend," because he would be afraid that he might leave off worse than he started. Take a case like this,

and a man can tell the distances by experience — using these screws, turning them one or two lines, without even stopping the card — and gets the result he desires in one or two minutes. Now, then, we recommend the use of these screws for setting until it passes six or seven lines on the disc; then we find the cylinder out of centre just about one one-hundred-and-fiftieth part of an inch. The divergent point is so small, however, you can hardly distinguish it on a drawing. My point is this: that we have here a great practical convenience without any practical evil result. Now, when those six lines are passed we know exactly the difference in thickness of band to put on to make the equivalent, because the bands coincide with these marks with respect to thickness, etc. We put on a new band, then we go down to zero, and so on. We do not need to change the band oftener than once in two or three years. You can easily get at this talked of "difficulty of setting the Ashworth card" from that. These bands are all numbered, — 24, 25, 26, and so on. To tell you just what the difference is between one and another, No. 24 is a five-hundredth part of an inch thinner than No. 25, and so on progressively.

I do not need, therefore, to read the latter part of this paper, except to say: [*Reading from page 23, referring to statement in paper that card at fair is just finished as every card made.*]

I must withdraw that remark. When I left home I gave our manager directions that this card should be just as we turn them out. When I saw that engine at the Exhibition I said to our man: "Is not that better finished than we send them out usually?" He said: "Yes, sir, it is." Well, now, you see he was tempted to put on a little bit of extra finish. But the only difference is in the front cover, which has a little more polish. Every other part of that card is just exactly as we turn them out. There is no electro-plate about it. Some one told me the other day that somebody had said it was electro-plated. This generally gives the idea that there is something underneath worse than what is on top. But when polish is an adjunct to good

workmanship it is admissible; when it is done to cover up bad workmanship it is not admissible. There are a good many cards which we have seen at different times which would need a good deal of electro-plating just to cover up some of their defective parts.

Some of the best English machine makers now attribute our results to using "Ashworth's wire." They have even come to that, at last, after all their opposition to our clothing. They say it is "Ashworth's wire" that produces the result on Ashworth's card. Before it was not worth that [a snap].

That, gentlemen, is all that I have written. I just wish to ask you to handle this question as you wish. Do not consider my feelings at all; just consider for the moment that I am a mere talking machine. Look at the facts and discuss the question as you like.

Mr. F. A. Leigh. I have listened with great attention to the paper read by Mr. Ashworth, and I feel that I must make some remarks on certain points he has brought forward, also refer to some personal reflections he has made in a recent circular issued to the manufacturers.

When I read a paper on carding two years ago I tried to give an impartial statement of the then present system of English carding, especially of the revolving flat card. I did not claim undue preference to what my father invented, but took what I thought to be an independent course. I had just returned from a trip abroad, where I tried to get the bottom facts, and made a lengthened examination of the cards made by the different makers, including Messrs. Ashworth.

I have made another trip this summer for the same purpose, and my opinion is stronger than ever that I did not make a mistake in my selection and recommendation of the Platt card.

I was surprised to find upon my return home that Mr. Ashworth had issued a circular criticising the Platt card and ridiculing my judgment on the matter, and I have since taken pains to confirm the statements of facts made in my former

paper, and see no occasion to change from what I then said, except so far as hardened and tempered steel clothing is concerned, where I acknowledge, by the result of experiments I have made here, my opinion has been changed.

I fully agree with Mr. Ashworth that any weakness in the construction of a carding engine is fatal to good work, but I think he will be the first to admit, in all fairness, that this defect cannot be attributed to the Platt card, as it is universally admitted that their workmanship and strength of materials used are not surpassed, and no other firm possesses tools and appliances to as great an extent.

As a proof of Mr. Ashworth's faith of the quality of their work, I believe he offered in the first instance the making of his card to Messrs. Platt, provided they would accept his ideas.

I am also surprised to hear Mr. Ashworth speak of the English machinists as "obstructionists," but perhaps it is accounted for, owing to his patented improvements not having been adopted by them.

Mr. Ashworth lays great stress on his method of fastening tops as opposed to lead rivets. Now I believe that Platt Bros. had Ashworth's system offered to them, but after their long experience with lead rivets they came to the conclusion that they were preferable, and fastening the clothing in this manner is almost universal, as it is simple and secure, of uniform tension, and preserves the solidity of the flats, since no cutting of the edges is required.

Another great advantage of this mode of fastening over Ashworth's, and a very important one too, is that when the iron flats require re-clothing they can be done at the mill, whereas it requires the flats on Ashworth's plan to be sent to England to their works, as a special machine and skilled labor is required to re-clothe same. The extra cost of this little operation, and the time taken up by same, is apparent to any one.

As regards the width of the flats to be used, I am fully confirmed in my former opinion that the 1 5-8 inch flat for American or Egyptian cotton gives better results than the 1 3-8 inch used

by Ashworth, and it is apparent that the broader is stronger and more rigid than the narrower. Elaborate tests have been made by Messrs. Platt with respect to quality and quantity produced, and rigidity of the flat, with the result I have stated.

A great deal has been said by Mr. Ashworth to depreciate the value of the flexible bend, but the more I have gone into the matter the more convinced I have become that it is the most perfect and simple form yet introduced, as it can be adapted to meet all requirements of setting and wear and tear, and is perfectly concentric with the cylinder in all positions, and is also quite rigid, despite his sneers about "crutches." Any one who has visited Messrs. Platt's works, and seen this proved, will bear me out in this statement. The actual movement up and down of this bend to compensate for wear of the card clothing is very small indeed, and especially so with tempered steel clothing.

Regarding Mr. Ashworth's mode of setting I consider it open to serious objections: —

First, it will be found impossible to keep the cylinder concentric with the bend. A cylinder weighing 1,000 pounds and running 160 revolutions per minute will soon wear sufficient to do away with the theory of setting to the 1-1,000 part of an inch.

If by any means the cylinder pedestals should wear sideways, then all hopes of proper adjustment are gone. Suppose for example the cylinder pedestal should wear 1-1,000 part of an inch to one side, the flats would have to be moved away that much, which would make 1-500 part of an inch on the other side. That the bearings do wear I am certain; as I was told that on some of Ashworth's cards I saw this summer they had to raise the pedestal up on one end only, viz., the other side from the driving pulleys; showing that the weight of the cylinder had been partially supported by the belt. These cards had been running less than two years.

Second, it is impossible to set the flats off near the licker-in by his arrangement, as some carders prefer to do.

Third, Ashworth's card will not compare with Platt's in

facilities of setting, the flexible bend being made to follow the cylinder, and adjustable at any point independently.

How much bending does the flexible bend require? You have, at most, only to provide for say 1-4 to 3-8 of an inch of wear of wire on cylinder and flats, and the flexible bend is turned between these two extremes, so that it has only to accommodate itself to a circle from 1-8 to 3-16 of an inch larger or smaller than the size it is originally made. Any one who has visited Platt's works and seen how these flexible bends are made and tested to the 1-1,000 part of an inch in all stages of their construction, will bear me out in saying that this mode of setting is perfect, and far more accurate than any other.

Referring to the question of production, I believe the Platt card has not been surpassed. We have cards producing, in several instances in this country, 870 pounds per week from the ordinary 38-inch lap, and in some cases we have done even more, making good work. I should be quite prepared to undertake to supply the same number of spindles with the same number of cards that can be done by any other maker. Personally, I am not an advocate of excessive production, as it is very often done at the expense of quality and extra waste, wear and tear. It is in my opinion preferable to have a few cards more, and card lighter, and thereby insure good work in perpetuity.

I should be very glad to give references on the point of production, quality and economy to any one of you, from mills not only here, but also in England, where the Platt card has proved an unparalleled success. In fact nothing has done more to bring out the merits of the Platt card than the opposition of Messrs. Ashworth, which is proved by the fact of the enormous demand made upon the Platts, who have now an output of over 3,000 cards per year; and we should like to know how Mr. Ashworth accounts for this fact, when even in their home trade they are busier than they have ever been before, in spite of his efforts to introduce his card into his own country. I have myself sold 1,200 of their cards in this country, and many of you

having been to England and investigated this matter for yourselves have only confirmed my judgment in the matter by giving me your orders upon your return.

Another important drawback to the Ashworth card is the long time and great expense incurred in setting each card to work. I believe I am within the mark in stating that it generally takes about a month, and with the finishing process described by himself as a "difficult" operation, and one only to be trusted to a skilled workman, it will be apparent that it is a dilatory and costly process. The Platt card we generally get to work in three days, — slightly different from a month. The finishing process referred to by him is as yet an experiment, and I fear has its drawbacks; and as regards the re-grinding on his plan, I am sure that it is not practical, as it is such a delicate, difficult and tedious operation that it could not be trusted to be done without injury to the wire by an unskilled workman. I am quite sure that we obtain the fine point desired, fully equal to his own if not superior, at considerable less expense and trouble.

Mr. Ashworth's remarks respecting the plan of the mill I referred to in my former paper are not apropos, as that mill was clothed with iron wire, and consequently required considerably more cards than would have been the case had hardened and tempered steel clothing been used. If this wire had been used of course there would have been a great saving of labor, owing to there being less grinding and stripping, and no more space would have been occupied than given by Mr. Ashworth in his plan.

I am told that the mill I referred to has now put on some of Sykes' wire; and they have found such a marked improvement that they are gradually replacing with it throughout, and when that is done both production and quality will be increased.

In Messrs. Coates' new mill Messrs. Ashworth state they have put in 140 cards, 44 inches wide, the mill having, I believe, some 80,000 spindles; and I understand that Messrs. Platt Brothers have furnished for a new mill of Messrs. Mus-

graves, for practically the same counts of yarn and the same size mill, only 144 cards, 40 inches on the wire; therefore, instead of Mr. Ashworth having less he must have about 400 inches more carding surface than is being put in by Platt.

In regard to waste: On this point everything depends upon the quality of the cotton used, and if there is an access of dirt, after scutching, requiring to be eliminated, then the card is the proper place to take it out.

I can most certainly claim to working the Platt card as economically, under similar circumstances, as Messrs. Ashworth can do, and to confirm this I have in my possession a letter just received from a mill here in which I am informed their waste is only 2 per cent., and that their cards are working very efficiently, with a production of about 20 pounds per hour. How much can Mr. Ashworth beat this with his card, which costs considerably more?

It has been found that we can work the Platt card with the ordinary skill found in the mills here, but I think it would require a special expert to adjust Ashworths', and in this my opinion has been confirmed by some of your members who have been to England and have spoken on this subject here in previous years.

I have been surprised that Mr. Ashworth should try and belittle my late father's inventions, seeing that he has used so many of them himself. My father invented coupling up the flats with the chain; making them of cast iron; cutting and milling the ends so that all could be set and ground alike; the flexible bend for adjusting the flats to the cylinders, instead of screws on each flat, as used by Smith of Deanston; stripping the flats with a comb instead of a brush, as Smith did; applying a brush for cleaning flats after stripping; grinding flats in their places while the cards were at work; the bushed chain for carrying the flats; he also covered up the brush for flats as Mr. Ashworth does; he suggested a slow motion for grinding the cylinders and doffers in his book on "Cotton Spinning,"

now so well known, and tried many other experiments too numerous to mention.

I have, I think, replied to many of the points brought up by Mr. Ashworth, and, therefore, cannot ask you to give me longer of your time.

Mr. Ashworth. I wish to say, in reply to Mr. Leigh's remark with respect to the circular issued, that our objection to it is simply because it was represented that Messrs. Platt & Co. made "many improvements, etc.," in this card as leading machine makers in all kinds of mechanical operations. And I just take his word: that the card as they made it then was just as his father left it, and that they made no constructional improvements on that. All the improvements suggested by the inventor were forced upon these machine makers. There was no change in the principle of construction. The results they got were from more accurate fitting, better tool work, etc., employing better workmen. But there was no change in construction; that is my point. The 83 flat card was forced on to them by ourselves and method of fastening. I admit I went to them to make our card as being the best machine makers in the country, and offered our flat system to them; but they adopt as a rule only those things they invent. Nobody supports the Platts more than myself with respect to the quality of their work. But what did they do? They did not want to do anything which would alter their own construction, and they wanted nobody else to. They tried hard to prevent narrow flat adoption, but they could not do it. They were compelled to make a narrow flat, and so they made the 83; and now, by the way, they make 100 and 104; they have been forced ahead, if you please.

Now, in respect to this fastening [holding a flat in full view], I ask anybody here whether a man can prove that a hand-riveted flat is better than that, whether there is a more equal tension. Why, in hand-riveting this is stretched bit by bit as they go on, and lots of these wires are indented by clinching the rivets.

In our case all this work is done by machine, staples made and secured; and there is a jaw which runs the whole length and stretches the whole length of cloth at the same operation; and then after that the fastenings are put in. Now tell me if any hand-riveting is as pretty as that? After you examine it tell me if there is any chance of the cloth raising? As for deflection, I will undertake to say that that flat will deflect less after it is put on than a wider, say one of Platt's 83 flat cards.

With respect to making little of Mr. Leigh's invention I have done nothing of the sort. I do not want to injure at all anybody's feelings. I wanted to put him out of the question, and I wanted him to put me out of the question, that is, our personalities. I have paid him just as much credit as he is entitled to for what he invented. What is there we have taken which is of any value? I wish he would point it out. There is nothing. The flexible bend had served well up to a certain point; but it is entirely unmechanical and unmanageable, I assert again.

As to the setting to the thousandth part of an inch, we never asserted it to anybody. However, people have got hold of it and have turned it into an argument against us to make out something which never existed. Because that screw, for instance, raises the cylinder a thousandth part of an inch, moving it from one line to another, people say that the Ashworths have said they can set their flats to the thousandth part of an inch. Why, gentlemen, the thing is preposterous. I know too much of mechanics to make that assertion; I know too much of mechanics to say we can set this machine to the thousandth part of an inch. It is a quantity almost ungaugeable. I will just tell you a secret with respect to that bend there, and then tell me after this whether there is no difficulty in managing a "flexible." Until lately we could not get that section of a circle so perfectly true that there was not a very small variation in the line of it. We never told anybody so, but we knew it, and we were not satisfied until we got it a perfect circle. Now, then, we commence to work on that bend in a very careful

manner, because to get any construction from a rough casting perfectly true you must know how you are going to begin, and you must know every operation, and what is going to follow it. We have had special lathes constructed to turn that bend. We do it as well as we are able to do it; and we are trained mechanics, have gone through the branches and think we know this work. Both I and my brother are practical mechanics, and we do it as well as we are able. And yet we never could, until lately, make that bend perfectly circular. We have one lathe out of all the lot which makes it nearly true. What do we do now? We have a special grinding machine and we put one each side on a steel mandril, and we can grind them up perfectly and dead true. Now I want to ask you, in face of faults in the work, in the way of making a flexible bend true, if gentlemen will tell you that they can manipulate that bend and make it follow that cylinder to the thousandth part of an inch? If any one is open to make that assertion, why, what can we think about it?

Now, then, take another thing. The bend spoken of by Mr. Leigh has been tested at Platt's shop, mind you, with flats off. You take it up to a certain point, then you take it down to this point, but there are no flats on it. But, gentlemen, that is not the question. The question is how can it be manipulated when the flats are on and you cannot make those measurements? What is the effect of the spring between the setting points? Now I know something about this, because while we were engaged on this card we had one after another several flat cards in our mill; and my brother and I have tried over and over again, for hours and hours, to see if we could set that bend concentric, and get all the flats at equal distances from the cylinder. In setting the flats to a bend we put a flat on three or four principal points set to a thick gauge; when all the flats are on they will be found to touch the cylinder, showing the weight of them deflects the bends between the setting points. If you get your flats a little bit further off the cylinder than the proper set you must go down in production from

900 pounds to 500 or 600. Flats must be either doing the work or spoiling it, and they are a very little off when spoiling it. We have often tested the flexible on this point and given it a thorough gauging. If you have supports under you may alleviate this evil, but it causes complication. When you take away those supports what do you find? How far have they done what they are intended to accomplish, and what does it all amount to? Simply that it minimizes the evil of deflection between the setting points. The point is important; not, do the flats touch here and there? but, what is the evidence of concentricity? Also whether a man can take down his six setting points so carefully, working with ordinary intelligence, that he can keep his flats as he ought to have them. The important question is that in the setting of these points, the vibration of the flexible bend when the card is working, the wearing of the slots at the ends of the flexibles, — that these evils altogether shall not bring down the quality of production of the card very considerably after two years' working. I am very glad Mr. Leigh confesses that he was quite mistaken in his estimate last year of the value of hardened steel wire clothing. Am glad that he now sees that this steel wire is the right thing. There is no doubt that will help the gentleman, but it will not get over the difficulty of setting the flexible bend. And as for any man telling us to our face that we cannot set our own bend, of course I do not know what to say. It is strange to have a man tell you we cannot do a thing that we know to be easy. Some people know more than we do evidently, but I have gone over it time after time, I have tried to demonstrate it, and the results in every case show exactly that we can do all I assert.

We have on the table there some cotton which has been carded at the Exhibition; the card is in a comparatively rough state, the card has only just been started. Cotton on this side has been done at the rate of 1,140 pounds in 60 hours, and there is a gentleman here who saw it; and that on the other side is done at the rate of 2,280 pounds in same time. I do

not recommend that. Why do I mention it, then? I just mention it for this reason: to show you that while the card, as ordinarily made, is weighted up to its extreme power, so that if you put on 100 or 200 pounds more weight the work is spoiled; this card is so strong, over and above the work it has to do, that it will still give the quality of work though you put on 200 or 300 pounds more. Then I have letters in my pocket showing what is being done, and I can show you where people in England have been doing over 1,000 pounds per week on our card.

Now, with respect to the waste. Of course it depends on the dirt. But I stick to my statement, that nobody can deny that we produce to-day less waste, cotton for cotton, and with less labor than any other engine in the market.

As to the starting of our cards, and as to the statement of Mr. Leigh that we cannot accomplish our hand-pointing, again he knows better than we our own capacity and business. Why I can do it myself, easily, and I have a man here who can do it, and we are daily doing it. And as to this difficulty of hand-pointing, it is very funny to me, because we have done before impossible things. I cannot help remarking that a man came to me a short time ago and said: "This surely cannot be done;" but we will do it for you, — do it for any one, and make a finish to astonish you. And yet we are to be told that it is a delicate operation and cannot be done.

And as to the question of time in starting, we do take longer; it takes us usually a week, not longer, to do that starting up; but any other card ought to have the same time. In this time given is not time lost. But when they are started, there is the point; they go ahead without being touched. We have plenty of cards in England which have run years with stripping once a week, — some once a fortnight, — and the work is magnificent.

I have no personal feelings at all against Mr. Leigh, and I do not intend at all or even desire to depreciate what his father has done. I have read his book as carefully as anybody, and

every other book upon the question. I simply wanted to state the plain facts, that he was not the inventor of the revolving flat card, and that he was simply the introducer of the flexible bend and connecting chain.

There is another point, as to putting on this flat clothing, which has been made some handle of,—that the clothing of flats on our plan is difficult, and that theirs is more convenient and easy. Well, we have completed by our industry or ability a machine to put it on which is perfectly automatic. It makes its own fastenings, and puts them in, and clinches them behind. This machine puts on a clothing in two minutes. In face of this we are told in effect that we cannot invent a machine to put on clothing on our plan by hand machine. We can make a much simpler machine and easier one to work than the hand-riveting one. We can make a machine — half a dozen forms of it — so that you can put this clothing on as easy or easier than by hand-riveting; and instead of its costing you four or five pence (ten or twelve cents) for the rivets, the wires to secure one clothing of ours would cost you about a half a cent. So, gentlemen, do not get it into your heads at all that you have to have Ashworths' men if you have Ashworths' machines; it is all rubbish and nonsense, and has been contradicted over and over again; there is nothing at all in it.

I do not know that there is anything else that it is worth while to reply to.

There is, however, just another point, and that is the wear of the bearings of the cylinder on one side. But I want to know where the point is, and why the objection is only against the Ashworths' card, and they cannot or will not see that the very same objection holds good against their own cards. Now you know how a card is set. I draw three lines. There is a doffer, a cylinder, and a taker-in, and they must be perfectly parallel. Now what takes place if the cylinder wears down on one side? It gets out of the parallelism with the others. This is true of all other cards. You cannot avoid it, and you cannot do anything to remedy it; but there it is, and theirs is

just as likely to wear as ours; more so, because they do not use such material as we use; they do not use such a splendid type of metal. We use a metal that costs three times the cost of brass and twice the cost of phosphor-bronze; and I say, with all due respect to our competitors, that they never made a machine to compare with this in quality of work. What do they do when their cylinder bearing wears? When it wears there is no remedy except a new bearing or the packing up. That is just the beauty of our system over theirs. As to side wear, however, we have no trouble from it. Your discussion did us some good, because we have remedied the side wear by a new method of driving, in which we divert all the pressure of the strap vertically towards the floor. Now, I say, we have the only proper method of driving, and we say that all the old methods are defective. In the examination of cases of the cards working in England we found many evil results of side wear in bearings. We obtain splendid results with our card, but it is quite essential that this cylinder be kept in position, and true in all respects, to maintain these results. Imagine a cylinder bearing having a little play and cylinder turned with a short and tight strap and driving pulley right over the one on cylinder. Can you say that whenever that is the case that cylinder will run true and steadily, or you can have good results? You have lots of cases like that; you have numbers of cards which wear there, along here, and at the side, owing to present driving. So you see these objections. Your discussion was very useful to us, because it showed there was a possibility that something might depreciate, and it set us to work to meet the possibilities. This driving is described in these circulars here; I shall be glad to have you take them, because you have all kinds of views there given. Now this is the leading principle of it [referring to the sketch]. You see we get all the pressure downwards towards the bottom part of that bearing, and using this method, in most cases, avoids the use of a cross-strap. For instance, at the Exhibition yonder, we bring the strap down this way, — in this direction [indicating]. We should have had to

use a cross-strap if it had not been for that driving. Now we retaliate on our opponents that is the only proper method of driving for a carding machine. The cylinder ought to be kept down in this way, and any wear can be taken up by these pillar screws. And don't imagine there is any difficulty about these guide pulleys. The work is not a "Jerry" job at all. The stud carrying the guide pulley is 7½ inches by 1½ inches diameter. We have a good method for oiling the carrying spindles, and we are able, owing to the plan, to work with a flat pulley on cylinder shaft. We and others always used, before, rounded face pulleys. Now a man can start his cards in one-fourth of the time compared to that before taken, because he can go along and put the straps on fast pulleys one after the other; and they do not require holding until the cylinder gets to speed. We get, therefore, the proper friction or full power of the belt, owing to using flat-faced pulleys. We can start the cards easily, there being less chance of slipping between belt and pulley, and more production from the cards on this account. I think, therefore, that this method pretty well disposes of the objection of the "side wear" in our card.

Mr. Leigh. How do you get rid of the side-pull on the belt?

Mr. Ashworth. Because it has a direct vertical action.

Mr. Leigh. Is there not a tight side?

Mr. Ashworth. That is a little tighter than the other, for a certain reason.

Mr. Leigh. A tight side, and that presses the cylinder to one side?

Mr. Ashworth. You cannot find it by gauge. It was tested.

Mr. Leigh. It would seem so.

Mr. Ashworth. There is nothing appreciable. Now then, we have on these sheets here the thing rather better described. We have straps driving from all directions, pulley here, pulley there, and so on.

A Member. How would they drive it with a cross-belt?

Mr. ASHWORTH. We do not drive with cross-belt; there is never any need for it. If you go to the Exhibition you will see we would have had a cross-belt except for this method. We do not drive with a cross-belt except in one case, when the pulley is just over the top of the main cylinder of the carding engine. In all other cases we need no cross-belt.

Mr. KILBURN. Why do you need to have it in that place? Why not have one on each side?

Mr. ASHWORTH. I cannot remember that, Mr. Kilburn; there is some reason, I cannot tell you just at this moment. I hope Mr. Leigh will not think I have any personal feeling against him. I want to deal with this question on its merits. I shall be glad if gentlemen will make an examination of these yarns at their convenience.

Mr. EDWARD W. ATKINSON. I do not know how far the members of this Association like to have their meetings resolve themselves into controversies between different machinists, or their representatives; but there are one or two points I would like to bring out that I do not think have been brought out in this discussion. Mr. Ashworth has attempted to ridicule the flexible bend in all forms; to say that it is of no use; and that is is worthless.

Mr. ASHWORTH. Comparatively worthless.

Mr. ATKINSON. Now I think there are flexible bends enough working and producing, both here and in England, to place this part of the card far beyond the bounds of ridicule. And if we undertake to credit everything that Mr. Ashworth says, I do not understand why all the English spinners have not thrown away every other card they have in their mills and put in his.

Mr. ASHWORTH. Give them time.

Mr. ATKINSON. Now, on the contrary, to-day there are plenty of spinners over there ordering Dobson & Barlow's, Platts' and the machines of all the other makers. Now Mr. Ashworth says that he uses that screw underneath the cylinder pedestal partly to take up the wear. I think that, in the cards

running and in use made by the Ashworths, the screw under the cylinder pedestal is used quite as much, if not more, for the purpose of setting as for taking up the wear in the bearing.

Mr. Ashworth. Very likely.

Mr. Atkinson. That being the case, Mr. Ashworth has said himself that you do not have to take a band out oftener than once in three years. That requires that the pedestal be set up at intervals for a period of three years. Now suppose you do that. You raise that cylinder axis up out of the true centre, and the theory of concentricity is at once upset.

Mr. Ashworth. Yes, certainly.

Mr. Atkinson. You raise the cylinder up close to the flat, right over the centre, and you leave the flats at the back and front standing away from their work. That is a small variation, I will admit; but it is just as much a subject of ridicule as the variation of the flexible bend. When I described the Dobson & Barlow cards here, two meetings ago, I tried to bring out the point that the ordinary style of flexible bend was defective, and that Dobson & Barlow had for years put in an intermediate support, which Mr. Ashworth has called a crutch, in their ordinary card, in order to remedy as far as possible this defect. Other makers have since followed them in this. But in Dobson & Barlow's new "Simplex Carding Engine," which is quite a different thing from the ordinary card, the flexible bend is made so that its concentricity with the circle of the cylinder, in any position of the wire, is absolutely insured, Now this bend is two inches in depth and seven-eighths of an inch wide; there are five supports, each, one foot apart.

Mr. Ashworth. I know it.

Mr. Atkinson. And the amount of variation in that flexible bend, by the weight of the flats, I maintain, is no more appreciable than the amount of variation that Mr. Ashworth has to admit in his card. Furthermore, he rather sneers at the idea of electricity being used, in any way or shape, for any purpose.

Mr. Ashworth. No, not in any way or shape.

Mr. ATKINSON. Now the electrical micrometer affords a very valuable means for testing the flexible bend.

Mr. ASHWORTH. Will you just explain where the value comes in and how it is used? I want to know, that is all.

Mr. ATKINSON. A flexible bend is tested in the following manner: it is mounted without the flats, as Mr. Ashworth says, upon the cards: in its original position, as it would be with the long wire. The micrometer screw is then put upon the cylinder after the cylinder has been mounted in its bearings; the micrometer screw is screwed down to such a point that the spark will just not pass between the flexible and the point of the screw. The cylinder is then revolved; thus testing the concentricity of the flexibles in their position. The flexible is then lowered slightly and a similar test made; and so on, till it has been tested in every position that it will be required to assume in actual working in the mill.

Mr. ASHWORTH. That is for testing the bend. Will you just show the value of that over a plain mechanical test?

Mr. ATKINSON. I do not know what you mean by "a plain mechanical test." I did not state it was better than any other thing; I stated that it was a very valuable means of testing,—one that was not subject to ridicule in any way. Now as regards the setting of the flats, it is a very important thing to have those flats —

Mr. ASHWORTH. You mean when the card is working at the mill?

Mr. ATKINSON. No; I mean when the flats are made. It is a very important thing to have them bevelled and cut properly. I say electricity is a very effective means of testing them there. I do not say that you have not got a better one. You may have; but I doubt it. It is all very well to talk, but I have found it a very useless thing to talk about what people were doing in England. We have got to discuss things theoretically, as far as the Ashworth card is concerned, until practical results are attained here. I think this is the basis to go upon. Now, as regards the clothing, as I understand, — I do not pre-

tend to be an expert, — but, as I understand Mr. Ashworth's method of grinding, he grinds down on the sides of the teeth and the back.

Mr. ASHWORTH. Sometimes on the back; usually on the sides.

Mr. ATKINSON. And he does that in order to get plenty of room for the cotton to lay in. That is so, is it not?

Mr. ASHWORTH. Yes.

Mr. ATKINSON. Now we will take a cylinder that you are clothing for ordinary work, say 64,800 points per square foot, 10 crowns per inch of, say, 33° English wire. In a square foot of that clothing there are 144 square inches. Now what part of this area of 144 square inches does the wire itself take up, before it is ground at all? If you will calculate this, taking the diameter of 33° round wire to be 8-1,000 of an inch, it will be about four square inches of solid steel as against 140 square inches of foundation. Now all that can be gained by grinding on the sides alone is to eliminate this four square inches. Suppose you eliminate three inches by side grinding, you have got only 3-144 more space for the cotton than you have with common round wire that is not ground at all. Now it does not seem to me that this will give such marvellous results as compared with wire ground in the ordinary way; and as to grinding to a needle-point —

A MEMBER. If you will allow me to interrupt you, please explain what you mean by "needle-point?"

Mr. ATKINSON. I will accept Mr. Ashworth's definition of needle-point: and I quite agree with him, that needle-pointing is a sort of a catch-penny device to sell clothing by; and I should agree with him more fully if he would just include his own wire in the same category with that of other makers.

A MEMBER. What I have always understood by needle-point was a point similar to a point of a needle used for sewing clothing. If that is what it is, please say so.

Mr. ASHWORTH. Mr. Atkinson, will you not use the term fine point?

Mr. ATKINSON. Fine point; I will use that. It seems to me that the most important thing in clothing is to get the wire properly set, so that the rows and furrows shall be exactly in line, to get the proper bend on the wire, suited to the quality of cotton that is going to be used, and to get the proper foundation, and an even temper. When you have these things right, I do not think anybody will ask for needle-pointed wire. To conclude, I maintain that the improvement in the setting of the card, which Mr. Ashworth has described, is theoretically incorrect; and it does not seem to me that the use of his cylinder-pedestal, and his so-called improvement in needle-pointed wire, are going to produce any such wonderful results over any other card; and I say they don't do it. I make that statement.

The PRESIDENT. Mr. Atkinson prefaced his remarks by saying that he did not know how far the Association liked to have its time taken up by discussions between rival machine builders. That is a thing about which there has been a good deal said in the past, in this Association. But I see no other way in which the Association can get the merits of the respective machines so well brought before it as by permitting the men who are perfectly familiar with the details of construction of each machine to discuss the question in open meeting. There is present to-day a maker of card clothing, Mr. SYKES, who has been alluded to in some of the remarks that have been made before; and if the meeting is in favor of permitting Mr. Sykes to make a few remarks upon card clothing, with a view to the better ventilation of the subject, I should be very glad indeed to have them express it by an affirmative vote. Mr. Sykes, you will understand, is not a member of the Association, and is not present by invitation of the Association; he happens to be here, and would like to say his say so long as his card clothing, which is not unknown to some of you, has been attacked. Those who are in favor of permitting Mr. Sykes to make a few remarks on the subject of card clothing will indicate it in the usual manner.

The Association voted to hear Mr. Sykes.

Mr. Sykes. Mr. President and Gentlemen: I first wish t thank you and the members of this Association for affording m this opportunity of addressing you. I only arrived in this cit so lately as last Sunday and had no idea of attending th meeting, let alone being asked to take part in this discussio and I am naturally, to some extent, at a disadvantage. I su pose I also should thank my friend Mr. Ashworth, as also m friend Mr. Atkinson, for the very kind manner in which the have been good enough to allude to our native city. Howeve I do not propose to follow Mr. Ashworth in the course he h adopted in this matter, because, with due deference to all you, I think this is neither the time nor the place to discu such matters. As I understand the object of your meeting is merely to arrive at the truth.

Now I am perfectly content with the position which our ca occupies, not only in this country but in every country; and am content that we have a reputation for our card second none, and I can offer no better evidence than the actual use them. If nothing succeeds like success, why, it is a fact whic Mr. Ashworth will not deny that we are far beyond him putting in these cards with steel needle-pointed clothing, a that the demand for our card clothing has been so gre that during the last year we have scarcely been able to me it.

Mr. Atkinson seems to know a little bit more about needl point than we do. I only need to state this fact, gentlemer that I believe there is not a card maker or a machine maker any card in England who has not adopted the steel needl pointed clothing. That is, I think, a sufficient answer. Messr Dobson & Barlow are alone, almost, the exception. In fact know we make clothing for Messrs. Leigh & Co., who no never sell anything else; we sell to Platt Brothers; we sell to tl Hetheringtons; to Howard & Bullough; and to many other m chine makers. So that is the best evidence. Theory is o thing but practice is another thing. We know what we get

results. On that point I think you will trust the card makers to know what they are about.

Mr. EDWARD W. ATKINSON. I do not dispute that.

Mr. SYKES. You confess you are not an expert, sir, and I accept the fact.

Mr. ATKINSON. I do not dispute that it is a good thing in its way, and is being largely used. But that it is any better, or that it is as good, as a first-class steel wire ground in the ordinary way I do dispute; and maintain that it involves many serious disadvantages which the ordinary grinding does not. Though good results are attained with it, the same are attained with the ordinary grinding, and much more capital is made out of the needle-point than its supposed merit warrants. There is one more question I wish to ask Mr. Sykes. How is it possible, in grinding this fine wire on the sides to a needle-point, to absolutely insure that the grinding shall be done just as much on one side of each tooth as on the other, so that when the grinding is finished every tooth shall be left exactly the same length as every other tooth? I maintain that this is impossible with the present method of grinding and is a serious drawback to the needle-pointed wire.

Mr. SYKES made no reply.

Mr. SYKES. I have made a few notes, and, as I say, I do not wish to go into personal reflections. On this point I may just say I think we have made and sold steel needle-point cards fully to the value of $1,000,000. That of itself is a sufficient statement. All others must have made not quite $500,000 worth. In any single instance I could not put my finger on a mill where there has been a partial failure. If there is a gentleman who can contradict that in this country I should be glad to hear it; I should be sorry to hear it, but I give that challenge.

Turning now from these personal questions, for I feel it would be an undignified discussion if I were to go into these personal matters, I must give the Ashworths credit for the introduction of steel wire. There is no doubt that the Ashworths

were the leading people in the introduction of steel wire, and it is only fair that it should be acknowledged, because there can be no doubt, I think, that it is to the adoption of steel wire more than to any other thing that we owe the improved results which have been obtained in carding. There is no doubt that except for the fact of steel wire being brought into use in the manner it has been, the enormous production of the cards and the increased efficiency would not be what it is to-day. We have clothed all makes of engines; very largely, too. We have made, as I said before, clothing for the Hetherington and over a thousand of Platt Brothers' make, and for all the different makers; and, bear this in mind, every maker has been able to show increased production and an increased quality. That shows you that with steel needle-pointed clothing they have been able to accomplish what they never did before; and it is this which is improving the revolving-flat card in a very great measure since it has been in use, — that is my opinion. Now in regard to this question of more or less production. Like Mr. Leigh, from my experience I am not an advocate of this excessive production. As a matter of fact, whatever Mr. Ashworth may say, these excessive productions are not looked upon with favor in England. It is far better to put in more carding and so do better, for so you can start with a certain production and maintain it. It is all very well to nurse a single card. You can nurse a carding engine and you can get excessive production. But what you want is to be able to have a mill full of carding engines and know that you can get at results week after week continuously and always satisfactorily. That is the point that is required. It rarely happens in England that any spinner attempts to do more than fourteen or fifteen pounds an hour on a 40-inch card. I think if they can do that on the improved engine it is all that is needed or required. It is not necessary, but I did make some remarks about Mr. Ashworth's theory. I am not speaking to you, gentlemen, simply as a card maker, because I have had a very large and extended experience as a cotton spinner. Had time permitted I should

liked to have said that I did not agree with Mr. Ashworth, and given my reasons as a cotton manufacturer. I cannot accept the theory that he has enunciated. However, I think in a meeting like this it is a matter on which you will have to think for yourselves. I expect this matter will be treated by some other gentlemen present. I could accept his definition with regard to point, — that it is most desirable, in fact it is essential that you should have a good point to have a good card. If you get a good point and maintain that point then you have a chance to get good results. The fact of the matter is that the tempered steel with extra strength and extra rigidity enables us to set closer, and to accomplish the work with less grinding and less stripping. The amount of stripping is varied to a great extent. You cannot say how often you ought to strip or grind, the thing has to depend upon its own merits.

Mr. Ashworth had something to say in regard to his pointing. He says we have not adopted it. We have not. But I promise him that when I have found a superior one to that we have in use we will adopt it with the greatest pleasure in the world, because what we desire to do is to give our patrons the best possible card. I should like to say more, but I will not attempt to trespass upon delicate ground or to monopolize your time. I think Mr. Ashworth has had a fair chance on his part, and it is only fair that I should have said these few words I have spoken.

Mr. Edward W. Atkinson. May I ask Mr. Sykes one or two questions, simply for information? Whether he considers that it is necessary to have a disc grinder on a card after the card has been set up, in the ordinary grinding, or whether he would grind his needle-pointed wire with the ordinary traverse grinder or dead roller, whatever the case may be? And supposing he grinds it with the ordinary grinder, how, after successive grinding, what Mr. Ashworth has called the needle-point is kept? And, furthermore, another question; whether needle-pointing in itself, in the first place, does not roughen

the wire to a very great extent and make it more difficult to strip off?

Mr. Sykes. With regard to stripping it I can assure the gentleman we have no difficulty at all of that kind. We never have the slightest difficulty. I cannot put my hand on a single difficulty we have ever encountered. I do not know what has happened to you people, but in our practice we have never met that difficulty. With regard to grinding by discs, I think it would be a very unsafe practice to put it into the hands of unskilled men. In regard to Ashworths' device, I have not seen it and so I do not dare to express an opinion. Mr. Ashworth knows more about it than I do. That is one point I do not know about. But I will tell the gentleman that we have a little lever specially made for putting on the top of the wire that I guarantee to leave a good card when it is at work, after it has been ground, with the most perfect needle-point that has ever been introduced. Is there any other question?

Mr. Edward W. Atkinson. I do not understand. You take a card and grind it at the side or back. Then you grind it with the ordinary grinding device, and you are continually cutting that point.

Mr. Ashworth. The end of the wire fibre?

Mr. Edward W. Atkinson. Yes; cutting the end of the point down from a thinner to a thicker surface. Now, if the needle-point is correct in theory at the first there certainly ought to be provision for keeping the needle-point exactly as it was started. That is the point I wanted to bring out.

Mr. Sykes. In practice, sir, we get the thing right; and, as I said, if ever we do that we have an appliance for putting on to bring it up again.

Mr. Edward W. Atkinson. You do not say what the thing is?

Mr. Sykes. There are various notions as to the amount of wear. While the wear to the card is some, we certainly do very little of it; because, in the first place, before we needle-point it we get it perfectly true. That is the only regularity

that requires grinding. So we have the point of a grooved roll, which goes down between the wires, which picks up the point again.

Mr. EDWARD W. ATKINSON. Another point I want to ask about needle-point is this: how it is possible so to manage that all the wires will be of exactly the same length. If you undertake to sharpen a pencil and whittle off what is right on one side, and then turn it over to cut the other side, the chances are you will whittle off too much or too little. And I do not see how you get those points to exactly the same height all through. I have no doubt that you would be prepared to guarantee that they were, as I should, in the clothing I sell.

Mr. GARSED. Messrs. Sykes' card clothing was exhibited by me at Atlanta and also in Boston. I know the value of his card clothing, because I was an owner in a mill at a time when it was doing very poor work. In changing from the card clothing then used to that of the Messrs. Sykes', a great change was brought about in the mill. And the manager of the mill, with whom I am very well acquainted, told me: "Sykes' card clothing is something I feel proud to have." I then went to the Messrs. Sykes, — being an acquaintance, — I then went to Messrs. Sykes' works in Otisfield, saw the place, and he was kind enough to bring his prize card clothing to the hotel in Oldham, which I brought over here and exhibited; both at the Atlanta and the Boston exhibitions. The reason why it was not sold more was that when I told them the price of the card clothing, according to Mr. Sykes' statement given to me in Oldham, they said: "We cannot afford to pay that; we can get it made much cheaper here." Now all that I have to say is this: that the result in the co-operative mill, the advance they made after the change to this card clothing, I think, was very great. And the advantage is something to be looked at in the making of card clothing and the way it is cut off. After seeing this, going from one mill to another to see the grinding of cards, I saw at Otisfield this card-grinder which this gentleman speaks of as grinding in between the card teeth.

Well, that moves about an inch, and is rutted out so that
get very good working cards. I saw it in mill after mill. A
I saw this: that wherever Mr. Sykes' card clothing is adopt
so far as my experience goes, from people who are manag
mills in Oldham and in Boston, I heard this inquiry: "W
don't men use what they may rely upon, and get something t
is worthy of adoption?" And the whole thing comes to tl
that I think Mr. Sykes is the most experienced card clothie
England that I know of.

The PRESIDENT. I see the representative of the Mes
Whiteley, of Halifax, present here; and, as their name has b
mentioned in this discussion, I believe he claims the privil
of saying a few words. I have only to say there is anot
paper to be read, and that we shall be obliged to member
they will make their remarks as brief as possible.

Mr. F. W. THOMSON. Mr. President and Gentlemen
am exceedingly obliged to the chairman and to yourselves
allowing me to speak for a moment or two after my friend M
Sykes. And I take it that allowing both him and myself
speak is an illustration of the fact that science knows no peop
no nation, no language, and that we are all here trying
introduce the best process of carding, and that we are all h
trying to improve the goods we make and the processes
which we make them. The only subject I wish to speak up
is this: Mr. Ashworth and Mr. Sykes have referred to t
pointing of the teeth. I only got into Boston early on Sunc
morning, and have no samples here to show; but I am qu
prepared to show Mr. Ashworth or anybody else that the po
goes down about two-thirds of the way to the bend, instead
there being only an inappreciable amount taken off. I pulle
few teeth out yesterday, hap-hazard, without thinking what
going to take place at the meeting to-day; and the examinat
I have made of those teeth shows that the grinding had
down more than half way to the bend, and the amount that
wire was reduced was from four to six sizes. Mr. Ashwo
has said, and this gentleman who spoke over here raised

question, that you cannot get the teeth very much too close. Now in England, of course, the carding is almost all single carding, and on this side you card it twice, as a rule. And we find that, as a rule, you require fewer points to the square foot. In our own experience we have shown that if you get so many points in, there is not sufficient clearance between the teeth; and then you do not eliminate sufficiently the motes and the dirt in the web. I had a competition a short time ago with Mr. Ashworth's steel wire needle-pointed card clothing in a mill in Lancashire, and we clothed a line of a similar number, made by Howard & Bullough. They are working side by side, and to decide whether our point is a good one or not, the result is this: — and I have made frequent inquiry — both sets of engines are doing the same weight, they are both producing a very good quality of carding, and, in fact, you cannot tell one from the other. And the result of the test has been that we have closed with Howard & Bullough for at least 400 carding machines during the last eighteen months, and possibly a good many more; for the Platts, the Hetheringtons, the Lords, Dobson & Barlow and others. All of these are covered with hard tempered steel clothing, side ground. I do not know that there is very much more I can say on the matter without trespassing upon what has been said by Mr. Sykes; but spinners are finding out what we have found out before, — for we are large spinners as well, — that the needle-pointed card is carrying all before it. In this country there is a very large amount operated by our friends Messrs. Riley and Gray. We wish to give Mr. Ashworth the credit of being the gentleman who brought out the use of tempered steel wire, at the same time I hope you will give us older competitors an equal amount of credit for having done what we can to improve card clothing and the process of manufacturing it. And all I can say further, gentlemen, is that if any of you ever come to England we shall be pleased not only to see you at Halifax, but we shall also be pleased to see you at our mills where the clothing is at work, and not

only our clothing but Mr. Ashworth's, and then you can compare the results of the two cards.

Mr. KILBURN. There is one description of these methods of grinding which these gentlemen have failed to illustrate, which, it seems to me, will explain the difference in the two methods. After having seen both systems of grinding I find that one produces a point which partakes of an elliptical arch at the top simply, while the other maintains the form of a wedge. That is the difference between the two methods of grinding. It seems to me that covers all that can be said upon the two methods.

Mr. ASHWORTH. When the points are finished?

Mr. KILBURN. In one case it traverses over the wire and it rounds the point, whereas the other grinds it to an edge.

Mr. ASHWORTH. When the point is finished?

Mr. KILBURN. Your grinding makes each point partake of the wedge shape.

Mr. ASHWORTH. I say we send our cards out without the needle-point. We do not consider it is the right thing to put a finished point on a clothing before it is put on its cylinder where it has to work.

Mr. EDWARD ATKINSON. I am not competent to take part in the discussion of these details, but I may make two or three general remarks which will have some bearing upon the discussion. You may remember that when I made my first visit to Great Britain, in 1877, on my return I called attention to the vast superiority of the English method in the opening and picking-room, in providing sufficiently ample space and adequate machinery for preparing cotton for the cards. But without going into any discussion of the merits of English carding as compared with American, for which I was hardly competent, I then called attention to the superiority of the English carding engine as compared with the American carding engine; and I attributed the superiority of the English carding, in great measure, to the fact that the English manufacturer had learned it was better to pay a good price for the best machine, than to pay a low price for a badly constructed one. I remember that on my

return I asked why the English carding had not been to a greater extent adopted in this country. The answer made by Mr. Lockwood and others was, that we had not at that time operatives who were competent to run that machine; they had not been trained, and there would be difficulty about it. Now that seemed to me rather a poor way of getting off from adopting an improvement, but I could say nothing in answer to it. It seems to me that in this discussion to-day the merits of one special card have been opposed, because the cards are so much finer in their adjustment that we do not find in this country men competent to run them. That does not seem to me to be sound reasoning. If you are going to play second fiddle, and use second-rate machinery because you have not operatives capable of working first-rate machinery, it would be perhaps time to say that both the agent and the operative may learn their business better. And therefore I think that objection to certain of these carding engines because they are so finely adjusted and because they are so well made, is not very complimentary to the intelligence of the American spinners or carders. I take no stock in such objections. The man who cannot use the best machines had better go out of the business.

And now I say to you, that I suspect there has been in this country a general idea that each English carding engine is as good as the other; which is a mistake. As the margin of profits comes down in England, as well as here, it is necessary to have the best machines in order that they may save that last eighth of a cent per point, which may make the difference between running and stopping. A little money spent on the best card is as well spent on the best English card as on the best American card.

There are two classes of mills abroad that have corresponded, in some respects, to two classes of railroads we have here. There is one class of, so-called, co-operative mills, which are merely corporations under another name, which have been formed in all sorts of ways; partly in order to sell machinery; partly for the benefit of the promoters or constructors; and

partly to create a corporation corresponding very closely to speculative railroads. This system has already come to its I happened to be with one of the most experienced ban in Manchester the other day. Said he: "Last week the l est sale of 32s was made at the lowest price known, in rat the price of cotton; and that man's scalp must come off. is time that we had a good wholesome crop of bankruptcie order that the rubbish shall be cleared out, so that the best with the best mills shall have an opportunity to do busin I think you will notice the fitness of the remark. [Applau Therefore it has come to this in Great Britain: that the s tion of the best machinery of its kind, and the constructio the best adjusted mill of its kind, has come to be a necessit any profit that can be obtained from any work. This has to discrimination among carding engines and other machi and each machine-maker can only secure his business by proving on his own machines faster than ever before.

I have had but little time to devote to this subject, but I say to you that you have yet to learn what they have alr learned in England: that the highest-priced machine ma the best to buy, because it will produce goods at the least c corresponding to the rule that the best men in your mills, earn the highest wages that the state of the market will rant, are the men who make the goods at the lowest [Applause.]

I will suggest as to the matter of needle-point that in o that you may fully comprehend the discussion as it goes al it would be judicious to have some enlarged photogra views made of the various points in card clothing, and I t when you see them you will wonder which is the needle-p If you will take the different kinds of card clothing when are put in, and then take them at different stages in their from time to time, and compare one with the other, I t then you will have a chance to comprehend the merits of *pointed* discussion better than you do now.

Mr. GARSED. First, as to steel wire clothing. At the

meeting but one, I think, of the Association, I took exception to a statement by a friend of mine upon tempered wire. I think he did me the honor afterwards to propose that I be a committee of one to go to see some wire that had been running fourteen or sixteen months. Circumstances occurred a short time after under which I went to the mill, and he invited me to tell him which had been ground that week and which had been ground sixteen months before; and I am here to confess that I missed it. [Laughter and applause.]

While we are upon the subject of card clothing and carding, it occurred to me, if we needed more carding points, as has frequently been advocated, why not turn the licker-in upward from the feed rollers, instead of down; and thereby get an additional carding point between the cylinder and licker-in; instead, as now practised, a mere carrying, or transferring, point? Whether we want more carding points or not on each card is to me an open question; brought before me some months ago very forcibly on being asked to make a small card and spinning-machine, such as was used on Southern plantations forty or fifty years ago. This machine was made to take the cotton in the seed, gin it, card it, and spin it into yarn on four and six spindles. The point I wish to call your attention to was the carding part of the machine: First, there was a saw gin, about 10 inches diameter, 10 inches wide; next, a brush to clear the gin cylinder and transfer the lint or ginned cotton on to the card cylinder (this cylinder was 10 inches diameter by 10 inches wide, next a doffer 10 × 10 inches) and on to the two lines of rollers and spindles. It will be seen there were neither flats or rollers; and the yarn was pretty good, about No. 4s; quite equal in quality to some I have seen in larger mills. The machine I have described was made to go to Liberia, and, I believe, is now doing good service there. Now, if a cotton card with cylinder and doffer alone will card cotton, why do we go to so much expense to furnish more points? These are suggestions right to the point; but there is another which is a very serious one in this card discussion, and it was brought out by my friend

Atkinson just now, just as gingerly as he would handl
mouse; which is this: The wages of a cotton mill are ab
three or four times the interest on the investment in that cot
mill. You just cast over in your mind: How much wages
I pay a week and how much is my mill worth? And you
find that the wages amount to three or four times the entire
per cent. interest upon the cost of the plant. I reckon the int
est at six per cent. Now to what extent does that represent
best machinery that the world can produce, irrespective of
cost, if you can get some labor out of the mill? If you
run your mills with one quarter less labor, what difference d
it make whether you pay $1,000 for a card, or $2,000 fo
card, provided one will produce the result and the other
not? Now I saw a card yesterday, to which I might call y
attention. Upon very many occasions in this room have
advocated better workmanship. I think the last time I sp
upon that subject I said I thought the American manufactu
ought to make an attempt to make his carding better. A
said before, I have seen a card; a thoroughly made machi
as I think. It may be too well made for our ideas of to-d
but it is not too well made for our ideas of the future. I
country such as ours, with high wages and some other things
disturbing elements, it behooves us now to see whether we c
not get machinery into the mill and weed the labor out; not
much, probably, with reference to the care of these people, as
absolute money value you derive from it; because you pay y
wages here once a fortnight, and that in place of paying int
est once a year. If you will look at this machine and point
where some of its mechanical defects are, it will be for the
terest of the Association at the next meeting.

Mr. KILBURN. I fully appreciate the remarks of my frie
Mr. Garsed. I think he has got the best machinery. I m
compliment him on sending that new machine of his to Afr
rather than retain it in this country. [Laughter.]

Mr. GARSED. It is a benighted country, you know. T
machine was made at the request of a gentleman who serves

up excellent coffee in Philadelphia, grown in Liberia. We had some coffee and we discussed this matter of the difficulty of carding and spinning cotton there because they had no carding machinery. This machine made pretty good yarn; it carded and spun six threads at a time, and not bad yarn, — about as good yarn as I have seen in some larger mills. [Laughter.] The little machine was not a new invention, but was largely used prior to 1837 in all the Southern States. Now take the case of South America, a place where we must look for trade. As many of you are aware, large amounts of hides and tallow come from that country. They have no gas there. They have plenty of tallow to make candles of, but there is no machinery to make candle wicks for these poor benighted people. [Laughter.]

Mr. Ashworth. I want to make a few remarks before the discussion closes. First let me clear up the idea of personality. We are all friends here, I presume, and I hope we shall remain so. We are bound to bring in some personalities into one of these discussions, as a man must attach statements, etc., to an author by giving his name, — one cannot help it, — otherwise I would have called my opponents "One," "Two," "Three," if that would have pleased better. I came here for a certain purpose, and I told you what it was when I started out. Therefore I thought I was entitled to the floor for my known and avowed object. Now in regard to Mr. Atkinson's remark about other people using this card, let me say we have only been making them for about four years. Among the machine makers there were plenty who would but could not make it, and people who could but would not. We have, therefore, put down new plant to make the card as we think it ought to be made. With respect to Mr. Atkinson's remark about the fine set, these gentlemen all know we get our results by a perfectly nice set, and we have a splendid machine; and they are asking, therefore, how we can retain that fine set. Are you open to tell me, gentlemen, how, when a machine is make as correctly, almost, as a chronometer, it is going to require

more attention than a machine not so well made? We require a fine set to obtain great results, and we get these results. They know this, and they confound the results with the method of obtaining them; trying to make our difficulty of setting proportionate to our production; whereas the difficulties of setting this are very small, owing to the machine we have and true methods of construction. If we had been able to make fifty cards per week four years ago we could have sold them; because we could not make them people had to look elsewhere, and the other makers have been bound to step up, and they follow us as closely as they can. We do not alter cards as the Messrs. Platt do. This helps to to keep them busy. Another reason is, people are now putting in revolving cards where they used roller cards before. An English spinner, speaking of our card to an American spinner in my presence, said: "I have never seen a machine of any kind that has grown so rapidly in favor as Ashworths' card," and this is owing to the result we obtain. And the gentleman gave particulars of the ratio got from Platt's new cards as compared with ours. Mr. Atkinson, Jr., says he considered for some time that the flexible bend was not right, but now it is right because Messrs. So-and-so make it. I want also to refer to Mr. Sykes' remark about production. I believe as thoroughly as that I am standing on this floor that this production in our case will be kept up. We have not a single case where we have started at 900 and come down; but we have gone forward. Steel wire has some roughness, as Mr. Atkinson suggests. It takes some time to wear that off; but from the time it is put in, for two or three years it improves, and then you get your best results. So I differ from Mr. Sykes, and I am quite sure, gentlemen, that in our own case we shall keep these results and even exceed them. We have not a single case anywhere where we have had to go back an inch; if you doubt it, I can give you a dozen or twenty names of parties to whom you can refer.

Mr. Leigh. There is one question I would like to ask you.

Of course, when I was in England this summer I saw a good many of your cards, and I was told what the production had been.

Mr. ASHWORTH. What was the result? Name them.

Mr. LEIGH. Well, at the Mutual Spinning Company's mills, at Heywood, I was told they were put up at 1,000 pounds a week, and they have reduced to 860 pounds.

Mr. ASHWORTH. That is true, and there was good reason for it.

Mr. LEIGH. Then there is the Oldham Road Mill Company, at Rochdale. Those were put up at 1,000 a week, and when I was there those had been reduced.

Mr. ASHWORTH. I don't know about that, and I don't believe it.

Mr. LEIGH. Not only so, but I saw they had raised the cylinder on one side only.

Mr. ASHWORTH. Why?

Mr. LEIGH. Your people did it; I don't know why.

Mr. ASHWORTH. What do your people do to raise the cylinder up at one side only?

Mr. LEIGH. Well, we can. On the question of reduction, as Mr. Sykes said, I have been told it had been done.

Mr. ASHWORTH. As to the case of the Mutual Spinning Company, it was because they had few cards in, and they had to begin with them and get a certain weight from them. I have got samples of their yarns here.

Mr. LEIGH. Have you got any of their work?

Mr. ASHWORTH. Yes; 50s and 60s filling and 42s warp.

Mr. LEIGH. Do you know what they are doing at present?

Mr. ASHWORTH. They are doing about 900 at present.

Mr. LEIGH. Less. I got the number of hanks, also.

Mr. ASHWORTH. I know nothing of number of hanks; I have to do with weight carded. The point is, we have the best production. As this company has been mentioned I will read a testimonial from them.

THE MUTUAL SPINNING COMPANY (Limited),
HEYWOOD, ENGLAND, May 2, 1887.

Messrs. ASHWORTH BROS., *Manchester.*

DEAR SIRS: — We have pleasure in stating, in reply to yours of the 30th ult., that we are well pleased with your carding engines in every respect. Experience has, so far, borne out the favorable anticipation formed of them. Our counts are from 36s to 60s, and the weight carded per engine is over 800 pounds per week of 56½ hours. They would do more, well, if we required it. Yours faithfully,

ROBT. LIVSEY, *Secretary.*

Mr. LEIGH. Haven't you a large interest in that, sir?

Mr. ASHWORTH. Yes, we have, and we are open to take stock in every new mill which puts in our card [laughter], if we have the money. I will read you a testimonial from one in which I have no interest at all, if you like.

THE WARTH MILLS, BURY,
LANCASHIRE, ENGLAND, May 4, 1887.

Messrs. ASHWORTH BROS., *Collyhurst, Manchester.*

DEAR SIRS: — We regret not having replied earlier to your letter of April 29th, our Mr. Mellor being from home. We have much pleasure in certifying that the patent cards made by you for our respective mills fully bear out your representation of them. They will card 1,000 pounds per week of yarn from middling American cotton, and if properly attended to the work will be of the best kind. If further information is required you are welcome to refer parties to us. Yours truly,

Per pro. J. & J. J. MELLOR (Limited),
EDWD. W. MELLOR, Director.

May I read just one other before I finish? These are Platt's cards to which ours are here compared.

PORTWOOD MILLS,
STOCKPORT, ENGLAND, May 12, 1887.

Messrs. ASHWORTH BROS., *Collyhurst, Manchester.*

GENTLEMEN: — We have had sixteen of your cards working for over twelve months, doing 900 pounds a week carding, equal to 500 pounds. We are doing off what we consider the next best revolving flat

card to be had, and your cards have only been ground, and that very slightly, once since they started. They are only stripped three times a week; the others are stripped four times a day. Yours truly,

T. & J. LEIGH.

Now I have nothing further to say except to ask you to go to the Exhibition and examine our carding, point out its defects, and tell me whether you think we can set that card ourselves. I have been told we cannot. Well, that is information to me. We can do it almost as well as we can work a problem in Euclid, — our method has science in it. I wish to say that the cotton we have there is not very dirty; but I wish to say that you cannot bring us cotton so dirty that we cannot cleanse it. I will cleanse it to your satisfaction and the card need not be stripped for a whole week; you shall be there to watch the machine do the work.

Mr. McARTHUR. There has been so much said about cards running very long without grinding, I think some explanation is needed. It appears to me that cards cannot run well that length of time, without being sharpened in some way. The card that Mr. Garsed referred to, that ran sixteen months, I fancy was sharpened by some method, — perhaps a steel wire brush was used. I believe the use of this brush would answer Mr. Atkinson's inquiry in regard to how the needle point could be maintained.

Mr. KILBURN. I have not been a believer in carding so large quantities of cotton, and I am somewhat sustained by the report that my neighbor makes, that he is using a flat card with Mr. Sykes' clothing, making 26 yarn, increasing the product from 100 to 200 pounds, and increasing the strength of 26 yarn from 67 to 74 pounds. I must say there is something to be learned. It had not been ground for fifteen months.

Mr. GARSED. By brush or otherwise?

Mr. KILBURN. No, sir; not in any form.

Mr. GARSED. The card I alluded to is in Mr. Kilburn's mill.

Mr. McArthur. Don't you use the brush on any card?
Mr. Kilburn. Not at all.

The President. A paper was to have been read by Mr. Ashworth upon a new dyeing process. It has been suggested that the reading of that paper be omitted, and that it be published in the Proceedings of the Association. Those in favor of that course will please signify it in the usual manner. Carried.

The President. In regard to what Mr. Ashworth has said about your coming to see his carding engine this afternoon, or at your convenience, at the Exhibition, I have only to say that I saw it last night, and it certainly is a marvellous piece of mechanical workmanship. I have telegraphed to Lowell to have a dirty lap sent down by express, and I hope it will be there this afternoon. I do not know whether they will be able to send a waste lap; but if so, I think Mr. Ashworth will have quite as dirty a lap as he will like to tackle.

If no gentleman has anything else that he wishes to bring before the Association a motion to adjourn will be in order.

Adjourned.

SUTCLIFFE'S

NEW PATENT AUTOMATIC DYEING MACHINE,

AND METHOD FOR PRODUCING DYED YARNS.

BY GEORGE ASHWORTH.

This new process for producing dyed yarns consists in dyeing cotton, woollen and other slivers of fibre in a particular form, and dyeing them in a machine perfectly automatic. To make my description as simple as possible, and because so far the method has been mostly used for cotton yarns, I give my account of what the process is in working this material. It would be necessary for this to bring before your minds the use of the coiler and its can, as used at the English Card. This can we will take to be thirty-six inches by nine inches. Into it we place a perforated tube two inches diameter, the same length as the can, namely thirty-six inches. This tube has a disc on the bottom end of the inside diameter of the can. The card delivers its sliver into the can and coils it on the tube. When this is filled, a disc like the one on the bottom is screwed on the top, and the whole is lifted out as a bobbin of sliver. This is the particular form in which this sliver is dyed by the machine. The machine consists of an accessible box, in which revolves a perforated shaft of the length of the tube on which the sliver is wrapped; and vats for mordaunting, dyeing and washing, as the case may demand. The machine is also fitted with a centrifugal pump for forcing the mordaunts, dyes, etc. The bobbin of sliver brought to the machine is first covered with a cloth wrapper, and then put into the box named above. The strap of the machine is put on the fast pulley, and the machine dyes its material in about ten or fifteen minutes. The action of the machine is as follows: The shaft on which the sliver on the tube has been placed revolves slowly in the box. The

pump forces the dye up the inside of the tube, through its perforations, from the inside, through the cotton, to the outside; the dyeing material going back again into the vat. After a short time, the machine changes the course of the dye liquor; and is forced from the outside, through the cotton and the perforations of the tube, and runs down the inside, and passes through the inside back again to the vat. While the dye is passing through the material, the box holding it is revolving first in one direction and then the other.

I have stated above that this part of the process takes ten or fifteen minutes. After this, by greatly increasing the speed of the revolving bobbin of sliver in the box, the machine throws off, or extracts, all the dye; which also passes back again to the dye vat. If necessary, water for washing is applied in the same way. The sliver is then taken out of the machine and dried by an air-blower. The bottom of one end of the tube carrying the sliver is placed on the pipe of the blower, the other end is plugged up. The blower is set in action, and, by forcing air through the perforations from the inside to the out, the sliver is effectually dried. This sliver is then taken to the drawing frame and made into yarns in the usual way. There is some little difficulty with the material sticking, though this is now almost cured; but, after that, the working through is as easy as making the ordinary white yarns. It will be seen that this machine furnishes a good automatic dyeing process.

One man may mind a number of them. There may be fifty or sixty attended to by a number of comparatively unskilled hands, with the mixing and preparations of the dyes managed by a skilful operative. Though we have only named the dyeing of cotton sliver, the machine is useful for dyeing hanks of yarns, and other kinds of material. I have here on the table samples of cotton sliver in the form in which it has been dyed; with samples of colored yarns produced by this process.

I may say, in conclusion, that we have been appointed the sole makers of these dyeing machines, and we shall be glad to answer any further inquiries.

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